DRILLING AND PRODUCTION

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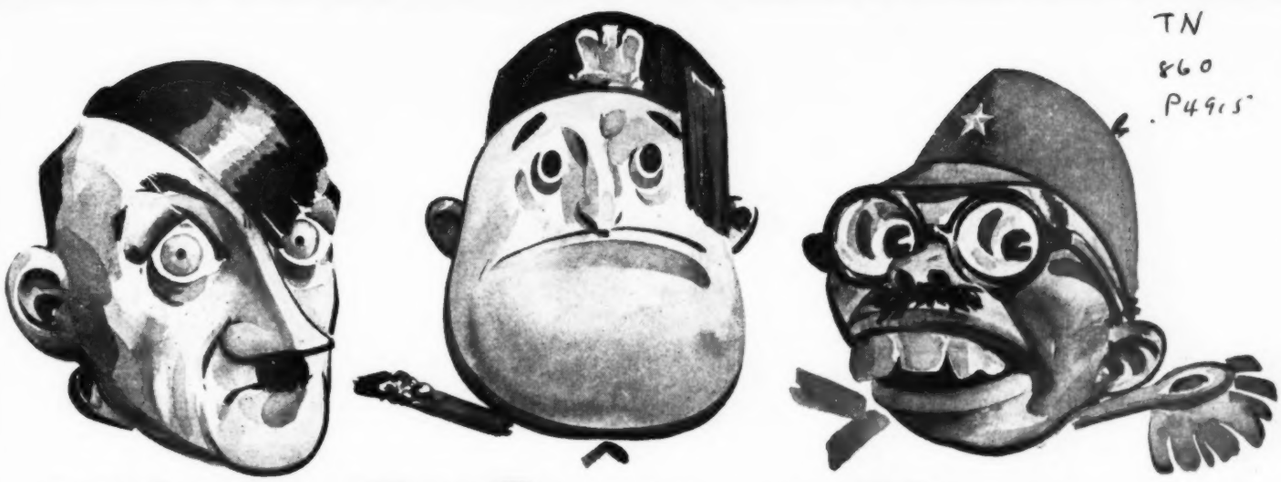

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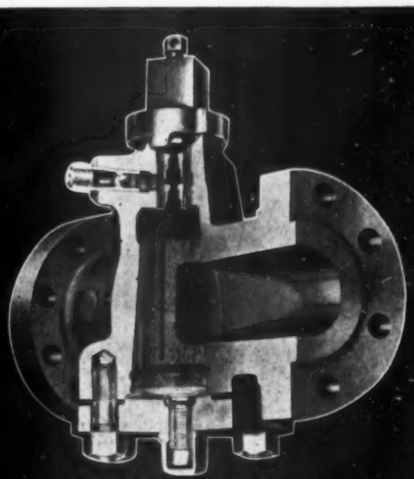

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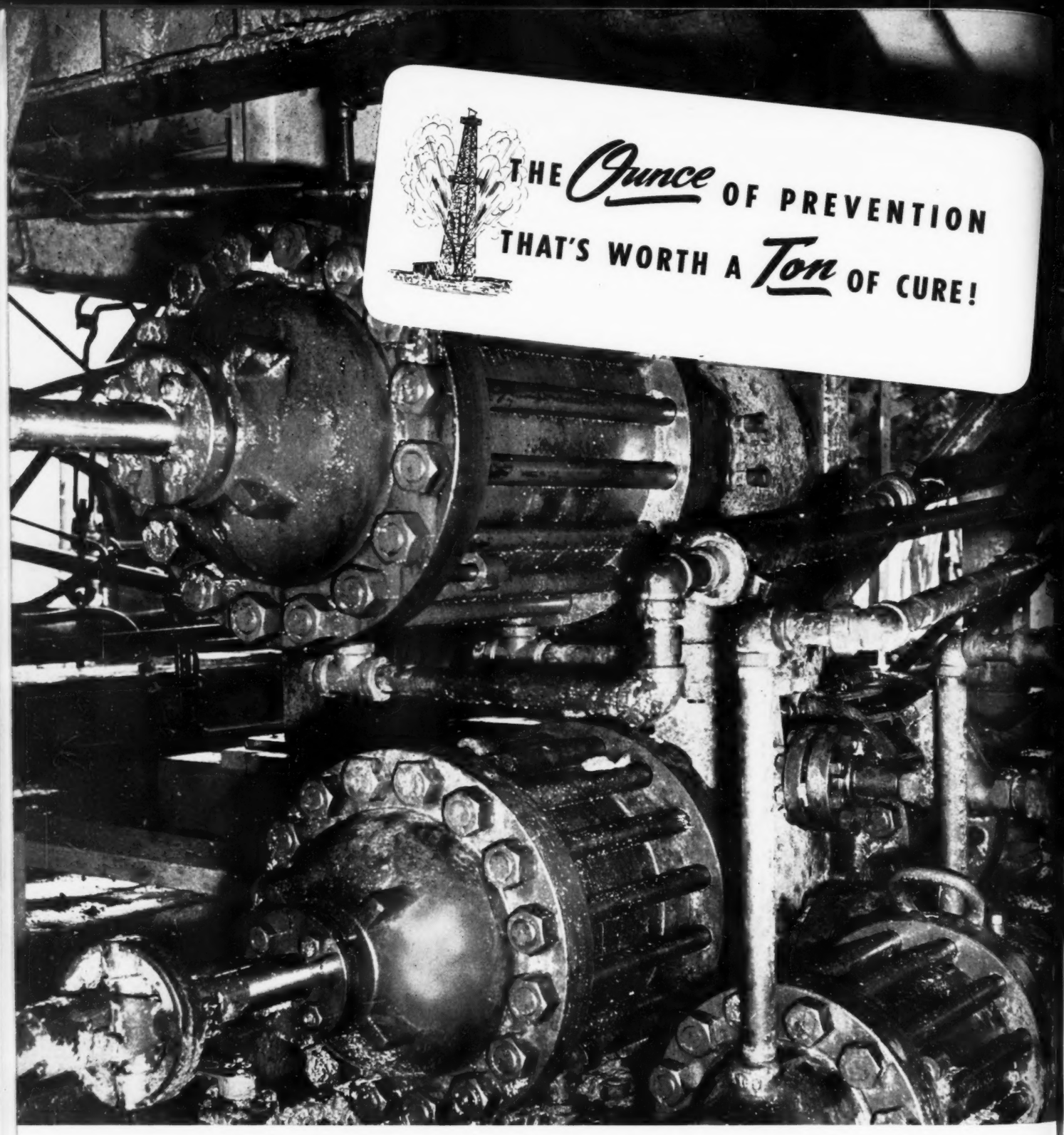

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January, 1943
(Annual Number)

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NOTE: Strict government censorship makes it necessary to omit definite locations of refineries, pipe lines, etc., from editorial matter.

MEMBER A. B. C.—A. B. P.

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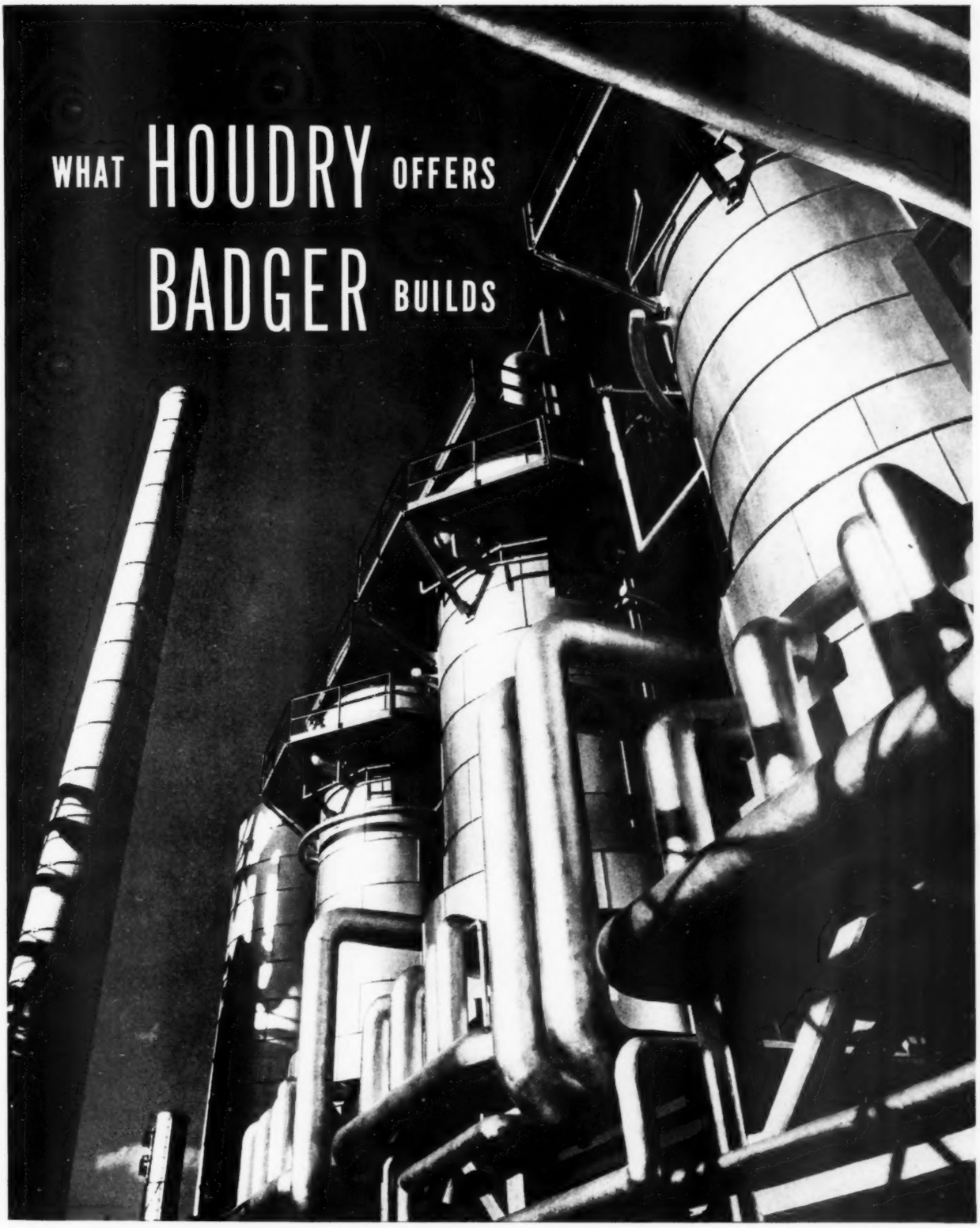

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PROCESSING ENGINEERS AND CONSTRUCTORS FOR THE PETRO-CHEMICAL INDUSTRIES

The Course of Oil

by K. C. SCLATER

STRIPPER WELL LOSSES

Reliable information on stripper wells in the nation as a whole has always been rather incomplete. Several months ago, the Interstate Compact Commission very wisely undertook, in coöperation with all the oil producing states, to fill this gap. The first compilation of data, the substance of a preliminary but enlightening report submitted by the Research and Coördinating Committee of the Interstate Compact Commission at the quarterly meeting held in Oklahoma City last month, is sufficiently complete to show the true status of stripper wells in the national picture.

According to the report, there were at the close of 1941 in the United States 294,211 stripper wells whose total annual production was approximately 208 million barrels and whose recoverable reserves were estimated to be about one and one-half billion barrels. It was also estimated that additional reserves that might be recovered from these stripper wells by secondary recovery methods, assuming an adequate price of oil, was in excess of two and three-quarters billion barrels. These additional reserves do not include the states of Louisiana and Wyoming; information regarding the stripper wells in these states was not available at the time the report was prepared.

In view of increasing war requirements, the continued operation of stripper wells is vital at this time—they accounted for 14.8 percent of the nation's total production in 1941. It is surprising, therefore, to learn that abandonments of stripper wells during the last two years have been much higher than normal, largely because of restricted crude prices. Oil reserves lost by stripper well abandonments during the seven years, 1935 to 1942, are estimated at more than 192 million barrels or about 27½ million barrels a year, and this does not include stripper wells in Colorado, Kansas, Louisiana, and Wyoming. The reserves lost by stripper well abandonments during the first six months of 1942 show how abandonments have been increasing under the present regime of price ceilings. During that period oil reserve losses amounted to more than 24 million barrels, or almost twice that of the average of the seven preceding years. This estimate also does not include stripper well abandonments in Colorado, Kansas, Louisiana, and Wyoming.

Most of these losses could have been avoided had the pleas of stripper well operators for an economic price for stripper well production been given just consideration.

ENCOURAGING WILDCATTING

In an effort to encourage wildcatting in Texas the Railroad Commission of that state at its monthly proration meeting issued an order effective January 15, 1943, fixing a scale of oil allowables for wells in new fields. The order applies to all wells in each new field discovered after the date of issue of the order. Each well drilled in such new field shall receive the new field allowable for a period of eighteen months, or until there are completed in the field six producing wells, each less than one-half mile from any other producing well. A further concession granted to such new wells is that they shall be exempt from all shutdown orders during the eighteen-month allowable period.

This order is expected to encourage wildcat drilling by rewarding the individual well making the discovery. It is also expected to encourage sufficient drilling to outline the producing limits of the discovery area and so indicate the size of the newly discovered reserves. By allowing a one-half mile extension to share in the new field allowable, the order is expected to have sufficient flexibility to allow other operators in the area to drill on their leases without necessarily ending the new field allowable and depriving the discoverer of his bonus for making the discovery. This, it is stated, should tend to eliminate one of the undesirable features of the present order, which is the drilling of a cluster of five wells and then stopping all drilling operations for one year, after which time under old field allowables it is almost impossible to drill wells because of the small daily allowables. The order should also allow the discoverer to cover drilling obligations under various leases without necessarily ending the new field allowable, thus protecting royalty owners against possible drainage during the new well allowable period. In support of the provision allowing wells one-half mile extension to share in the new field allowable, it is stated that it should not result in the addition of a greater number of wells, for the size of the average field discovered in Texas during the past two years was approximately six hundred acres. The one-half mile extension provision is designed solely to outline the producing areas of a new field so that if any sizable discovery is made its importance may be known and its reserves considered if the demand for Texas oil exceeds the optimum producing rate of the present known reserves.

This order is in effect an order by the State to encourage greater wildcatting activity, on the theory that development of new reserves is in direct proportion to the number of wildcat wells drilled.

P. A. W. AUTHORITY EXTENDED

Delegation of authority to amend conservation orders of the M-68 series to the Petroleum Administrator for War presages a revision of M-68 orders. More than likely an order will be issued soon requiring all wildcats to have a "certificate of necessity," in an effort to make wildcat drilling more effective and if possible reduce the percentage of dry holes. Whether such a requirement will attain its objective is problematical; if it does not, it may prove to be one more restriction that will hamper rather than aid effective wildcatting.

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Highlights IN OILDOM

Boyd Makes Year-End Statement

William R. Boyd, Jr., chairman of the Petroleum Industry War Council and president of the American Petroleum Institute, made the following 1942 year-end statement:

"Motorists are getting only part of the gasoline they would normally use, homeowners with oil burners are on short rations, apartment houses and factories have had to convert from oil to coal—but 'not one ship or plane or tank has failed to move on schedule for lack of petroleum products.'

"That is the job we set out to do, and so far the industry and the petroleum administrator, working together in what has become the most unique and effective industry-government team in Washington, have delivered the goods for the armed forces.

"So far as its normal operations are concerned, the industry set few new records in 1942 to accomplish this, but it is a safe bet that no oilman with experience in the wildest boom times of the industry's pioneering ever went through anything like the nerve-racking days of 1942.

"Transportation, and men, materials, and money, were the oil industry's basic problems last year, and there is no question but that they will become more critical long before they are entirely solved.

"Materials and man-power shortages have been plaguing every operating branch of the industry and steadily are growing more acute. The oil industry recognizes fully that it is entitled to no more materials than are absolutely essential to perform the job the nation expects of it, but in some instances we have felt that there has been a failure to understand these minimum needs.

"Daily we are losing skilled drillers, production men and refinery experts into whose skill has gone years of training. The man-power problem is one of the most serious now confronting the industry, and some solution must be found without delay.

"Specifically earmarked price increases have offset some of our increased costs because of transportation changes, but the refining branch of the industry particularly is incurring unique war costs that must be recognized soon by the government. The burden of manufacturing more lower-priced and less higher-priced products in a frozen economy is attacking the solvency of many of the smaller units of the industry, and actually is threatening their ability to produce.

"New oil reserves are needed at once, and studies are being made now to determine what incentives ought to be granted to encourage discoveries.

"Crude oil production, estimated at about 1,385,000,000 (billions) bbl. for the year, was slightly under the all-time record of 1,404,000,000 (billions) bbl. in 1941, and the approximately 20,000 well completions last year were only 60 percent of the 1941 total. Stocks of crude oil at the end of the year reached the lowest point in 20 years.

"For 1943, if we can produce it and transport the products, there should be a substantial increase in crude production. To meet even the rationed demand would require a rise of more than 400,000 bbl. a day by the end of the year, compared with the same period of 1942."

Ickes Praises Oil Industry

Secretary of the Interior Harold L. Ickes, in his annual report to the President, praised the petroleum industry for its coöperation with the government in meeting war demands for aviation gasoline and other oil products.

Ickes declared the industry had achieved "remarkable results" by junking normal patterns of operation.

After commenting on the war-born transportation and supply problems in regard to petroleum, Ickes said:

"In this connection, I want again to emphasize that the remarkable results that have been brought about would have been impossible without the wholehearted willingness of the oil industry to work in full partnership and understanding with the Federal Government."

Public Domain Lease Bill Signed

President Roosevelt has signed a bill designed to stimulate prospecting for oil on the public domain. Under its terms, a lessee who brings in a new oil field on public land, or who finds a new deposit of oil on an old lease, will have to pay the government only 12½ percent royalty for ten years after the discovery, whereas royalty payments under the old law ranged from 12½ up to 32 percent, depending upon the amount of petroleum found and its value.

Urges RFC Financing of Oil Exploration

Senator Joseph C. O'Mahoney of Wyoming has written Secretary of Commerce Jesse Jones, who also is chairman of the Reconstruction Finance Corporation, urging that RFC prepare a plan for financing independent oil explorations. He also wrote Petroleum Aministrator Harold L. Ickes and Donald F. Nelson, chairman of the War Production Board, advising them of his action and directed attention of all three to recommendations of the Public Lands Committee of the House of Representatives that immediate steps be taken by the agencies they represent to arrange such loans to stimulate oil production.

The committee recommended loans for not less than five years upon good oil land security, particularly to the independent wildcat operator otherwise unable to finance a drilling program.

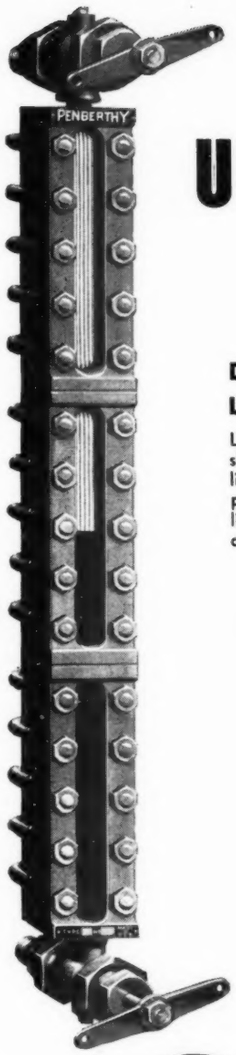
"It is difficult to use words strong enough to characterize the crisis which is developing in oil," O'Mahoney wrote Secretary Jones. "This is a crisis for which, in my opinion, there is no justification. We can produce more oil. We can refine more oil. To do this, however, we must find a way of strengthening the hands of those who understand the business of exploring for petroleum reserves."

Arkansas Orders Shutdown Condensate Fields

The Arkansas Oil and Gas Commission has ordered a production shutdown of the state's gas-condensate fields on March 1, which will be in force until desulphurization plants now under construction are completed. The plants, which will treat the sour gas output of the fields, are scheduled for completion in mid-June.

Fields affected by the order are the Texarkana, McKamie, Dorcheat (Cotton Valley and Lime), and Macedonia.

All allowables in the gas-condensate fields have been left undisturbed until the date of the shutdown and the commission fixed a daily allowable of 75,564 bbl. for the state until March 1. This provides for 23,999 bbl. for the uncontrolled fields; 47,024 bbl. of oil and 4,541 bbl. of condensate for the controlled fields.



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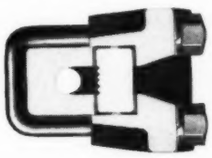

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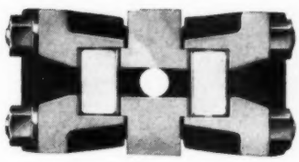

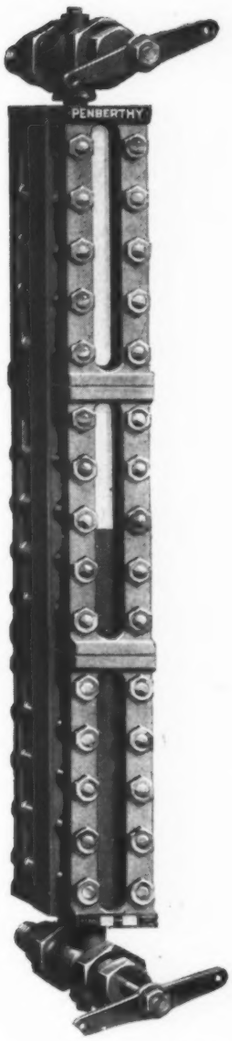

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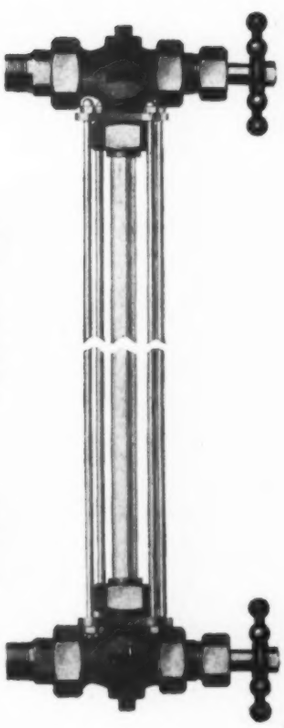

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PENBERTHY PRODUCTS

MAJOR *Refining* ACTIVITIES

THE Humble Oil and Refining Company's plant at Todd City in the Boggy Creek oil field, one of the oldest refineries in the East Texas Woodbine area, is being dismantled and moved to Bay City. Erection of the plant was in 1929 about two years after discovery of the Boggy Creek field. Operation of the old plant has been almost continuous, although production of the field has all but ceased.

Jesse H. Jones, secretary of commerce, has announced that Rubber Reserve Company has contracted with National Synthetic Rubber Corporation for the operation of a new government-owned synthetic rubber plant to be built in Kentucky by the Defense Plant Corporation, a subsidiary of Reconstruction Finance Corporation. Output of the plant will be made generally available and allocated by the government, together with the products of other government-owned synthetic rubber plants.

The National Synthetic Rubber Corporation was formed for the specific purpose of operating the new government-owned plant. It is jointly owned by five long-established rubber companies that manufacture a wide variety of products ranging from motor car tires to coated abrasives and including scores of articles of vital importance to the war effort.

Independent companies participating in the ownership of National Synthetic Rubber Corporation are Goodall Rubber, Inc., and Hamilton Rubber Manufacturing Company, Trenton, New Jersey, Hewitt Rubber Corporation of Buffalo, New York, Lee Rubber and Tire Corporation of Conshohocken, Pennsylvania, and Minnesota Mining and Manufacturing Company of St. Paul, Minnesota. The corporation represents a significant coöperative move among the independent rubber companies as a result of the war and the loss of crude supplies from the Orient. The companies are vigorous competitors in one or more fields of their activities. They have pooled substantial amounts of capital and have provided from their organizations a technical staff of outstanding ability and experience for management of the new rubber plant constructed by Defense Plant Corporation. Capital and staff for the plant were supplied by the five companies in approximate proportion to their respective size and range of operations. All have contributed important technical developments in various specialized fields, especially in the production methods for rubber products.

President of the new corporation is W. W. Benner of Lee Rubber and Tire Corporation and executive vice-president is Dr. B. J. Oakes of Minnesota Mining and Manufacturing Company. Oakes will also serve as general manager in charge of operations at the plant.

Reports to the Texas Railroad Commission have disclosed that several small refineries are being converted into plants for making butadiene for the manufacture of synthetic rubber. The plants now being converted have been estimated to produce sufficient butadiene for 120,000 to 125,000 tons of synthetic rubber annually.

The number of refineries and the prospective starting date for processing the butadiene were not given, however, the report stated that all except 10 of the 99 refineries in Texas are now making some kind of war material. Of the ten it is reported that probably two or three would be converted to butadiene production.

Judge Roy Hofheinz, after a hearing in probate court, has given approval of the sale of the Alice cycling plant in the W. R. Davis estate. The sale was to Skinner and Eddy Corporation at a consideration of $500,000. Of this amount $250,000 is to be a cash payment and $25,000 quarterly until paid.

A report by John L. Collyer, president of The B. F. Goodrich Company, states that another of the large-scale government financed synthetic rubber plants has begun production operations. This new plant, located in Kentucky, is considered an important unit in the Government's synthetic rubber program, which on completion calls for the production of more than 875,000 tons of synthetic rubber per year.

A synthetic rubber plant now under construction for the Polymer Corporation, Ltd., at Sarnia, Ontario, Canada, and representing several million dollars investment is expected to be completed and in operation by next summer.

The St. Clair Processing Corporation, Ltd., recently incorporated as a subsidiary of Imperial Oil, Ltd., is the third Canadian concern formed for the purpose of operating units of synthetic rubber plants being built by Polymer Corporation, Ltd., as part of the Dominion Government's rubber program.

Dow Chemical Company of Midland, Michigan, will operate the styrene plant and the polymerization plant will be operated by Canadian Synthetic Rubber, Ltd., which is jointly owned by Dominion Rubber Company, Ltd., Goodyear Tire and Rubber Company of Canada, Ltd., and The B. F. Goodrich Rubber Company of Canada, Ltd.

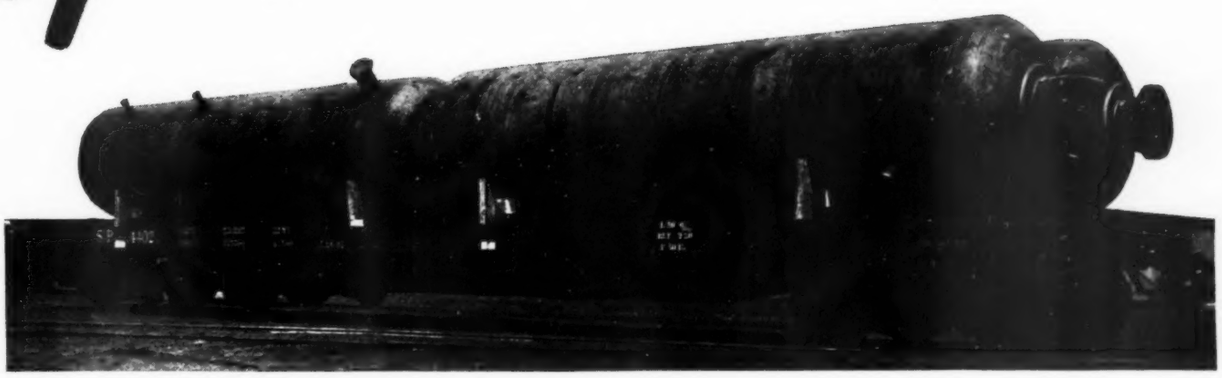
Crude Runs to Stills, Production[1] and Stocks[2] of Motor Fuels
Week Ended January 2, 1943
A.P.I. Figures

(Figures in thousands of bbl. 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Production	Total Gas and Fuel Oil Stocks
*Combined: East Coast, Texas Gulf, Louisiana Gulf, North Louisiana-Arkansas, and Inland Texas	88.2	1,678	68.8	10,138	71,066
Appalachian	84.8	160	90.4	807	4,124
Ind., Ill., Ky.	85.0	736	90.8	4,551	23,743
Okla., Kas., Mo.	80.1	335	80.5	2,105	10,023
Rocky Mountain	48.0	97	66.0	568	2,536
California	89.9	728	89.1	4,756	86,712
TOTAL U. S.—B. OF M. BASIS JAN. 2, 1943	85.9	3,734	77.7	22,925	(a)198,214
TOTAL U. S.—B. OF M. BASIS DEC. 26, 1942	85.8	3,525	73.6	21,231	196,989
U. S. B. OF M. BASIS JAN. 3, 1942	....	3,968	....	24,570	240,526

(a) Finished, 73,008,000 bbl.; Unfinished, 9,421,000 bbl.
*At the request of the Petroleum Administration for War.
[1]Production—total of gasoline at refineries including natural and blended; gas oil and distillate fuel, and residual fuel oil.
[2]Stocks—at refineries, bulk terminals, in transit, and pipe lines of finished and unfinished gasoline; gas oil and distillate fuel, and residual fuel oil.

Gulf Coast Bound



ON A WARTIME MISSION

PRESSURE VESSELS, like those shown above, are rolling to all points of the compass to take their place as integral parts of America's vital "war baby" industry . . . the synthetic rubber industry. The government's synthetic program calls for *speed* in producing the "instruments" necessary to convert raw materials into the precious rubbery substance. The experience, manufacturing skill and fabricating facilities at our plants have made possible the production of welded steel pressure vessels to meet many wartime production schedules in many types of wartime industries.

Complete facilities are available at our Birmingham plant for X-raying and stress-relieving as required by the governing specifications. Vessels up to 13 ft. 2 in. in diameter and as long as can be shipped can be handled in the stress-relieving furnace.

The pressure vessels above measure 5 ft. in diam. by 20 ft. long. They were fabricated for a defense plant located in a gulf coast state and are being used in the production of butyl rubber.

CHICAGO BRIDGE & IRON COMPANY

San Francisco	1019 Rialto Bldg.	Havana	402 Edificio Abreu	Cleveland	2237 Guildhall Bldg.
Greenville	York Street	Houston	5622 Clinton Drive	New York	3368-165 Broadway Bldg.
Birmingham	1542 N. Fiftieth St.			Philadelphia	1611-1700 Walnut St.
Chicago	2491 McCormick Bldg.	Tulsa	1603 Hunt Bldg.	Washington	330 Bowen Bldg.

Fabricating Plants in BIRMINGHAM, CHICAGO, and GREENVILLE, PA.

MAJOR *Oil Field* ACTIVITIES

KANSAS has a new oil pool in Hunter No. 1 owned by the Deep Rock Oil Corporation, a wildcat in NE NW SW of 20-16-1w, north of the Lindsborg area, but in southern Saline County, central Kansas. The well was shut in after a showing of oil in the Mississippi lime at 2674 to 2676 ft. was halted by a leaky casing. After the casing was repaired, the well was deepened to 2683 ft. in a new pay zone that filled the well with oil. Location of the well is one and one-half miles from the nearest well on a 2000-acre block.

The Kingwood Oil Company, Tulsa, Oklahoma, apparently has opened a new oil pool in Illinois with Niggli No. 1, C NE NE, 29-5n-5w, in Madison County, 10 miles northwest of the St. Jacobs pool. Twenty feet of coarse-grained saturated sand was found at a shallow depth of 570 to 590 ft. Operators plan to drill to the McClosky lime and then return to test the shallow sand regarded as the Weiler.

Henderson No. 1, NE NE NE, 31-58n-99w, in the Elk Basin pool of Park County, Wyoming, is reported as a most important oil strike in the Rocky Mountain area. The well was drilled by the Minnelusa Oil Corporation. A flow of 1200 bbl. of 30-gravity oil was obtained in 12 hours from the Tensleep sand between 4494 to 4538 ft. before the well was shut in for tankage. The discovery opens a new and prolific producing horizon in the pool. Production from the shallower zone in the field averages 28-gravity and the oil from the Tensleep is reported higher.

The Glenn H. McCarthy, Hankamer-McLean No. 1, Lopez survey, two miles north of the Stowell pool in Jefferson County, Texas, flowed 485 bbl. of 36.5-gravity oil on a 24-hr. gauge from 7836 to 7846 ft. to open a new pool for Texas. Total depth of the well is 8624 ft. with 5½-in. casing set at 7927 ft. Tubing pressure was 1325 lb. and casing pressure 1400 lb.

A new oil pool has been opened in northern Seminole County, Oklahoma, by Continental Oil Company and Kerlyn Oil Company, near Sylvan, Oklahoma. Scott No. 1, NW SW SW, 3-10-7, drilled to a total depth of 4510 ft. in the Second Wilcox sand, was plugged back to the Hunton lime and when swabbed began flowing into pits to clean. Productive status of the well was delayed until installation of tanks and pipe line connections were made. The well was cased with 6-in. casing set at 4178 ft. A drill-stem test between 4100 and 4200 ft. showed oil and gas.

The Gulf Refining Company has discovered a new gas and condensate pool in St. Landry Parish, Louisiana. Haas-Hirsch No. 1-E, at Krotz Springs, is now flowing through ⅛-in. choke from 9316 to 9326 ft. and is making gas and condensate. Previously the operator had perforated casing at 9317 to 9320 ft. and 9360 to 9363 ft. for squeeze jobs. Total depth of the wildcat is 10,700 ft.

AVERAGE CRUDE OIL PRICES

California		Louisiana	
Kettleman Hills	$1.23-1.29	Rodessa	$ .88-1.20
Playa Del Rey	.80- .87	Gulf Coast	.93-1.36
Coalinga	.73-1.13	North Louisiana	.98-1.30
Wilmington	.68-1.24		
Montana	1.00-1.15	Illinois	1.22-1.37
Wyoming	.45-1.15	Kentucky	1.32-1.43
Colorado	1.05-1.07		
New Mexico	.70-1.15	Indiana	.85-1.25
Texas		Ohio	
North Central	.97-1.21	Lima	1.50-1.60
Panhandle	.70-1.12		
West Texas	.80-1.27	Michigan	1.24-1.44
Gulf Coast	.93-1.48		
Darst Creek	1.14	Pennsylvania	
East Texas	.80-1.27	Bradford	3.00
Talco	.79	Southwest	2.65
Kansas	.93-1.25	Eureka	2.59
Oklahoma	.75-1.25	Buckeye	2.55
Arkansas	.94-1.36	Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

(Figures in bbl. of 42 gal. each)

	[1]P.A.W. Recommendations December	Week Ended Jan. 2, 1943	Week Ended Nov. 28, 1942	Week Ended Jan. 3, 1942
Oklahoma	403,900	[2]354,000	365,700	419,150
Kansas	300,700	[2]288,350	299,100	242,200
Nebraska	3,400	[2] 2,850	2,950	5,450
Panhandle Texas		90,300	89,800	87,850
North Texas		138,600	137,600	143,950
West Texas		206,750	212,750	292,750
East Central Texas		101,300	95,800	87,950
East Texas		350,600	354,800	369,050
Southwest Texas		177,500	176,550	217,000
Coastal Texas		311,100	313,400	295,950
TOTAL TEXAS	1,350,400	1,376,350	1,380,700	1,494,500
North Louisiana		93,150	96,550	82,400
Coastal Louisiana		223,000	228,700	275,450
TOTAL LA.	326,100	316,150	325,250	357,850
Arkansas	77,300	75,000	73,600	73,300
Mississippi	50,000	[2] 56,850	60,950	72,550
Illinois	274,100	254,600	255,650	388,350
Indiana	17,700	[2] 15,700	16,200	20,700
Eastern (Not incl. Ill. and Ind.)	107,600	93,300	90,350	101,950
Michigan	63,800	59,300	58,400	54,100
Wyoming	94,500	85,750	90,700	81,950
Montana	24,700	22,550	22,550	22,550
Colorado	7,000	6,500	7,000	5,550
New Mexico	99,700	93,350	95,800	118,850
TOTAL EAST OF CALIF.	3,200,900	3,100,600	3,144,900	3,459,000
California	815,000	770,000	733,100	579,000
TOTAL U. S.	4,015,900	3,870,600	3,878,000	4,038,000

[1]P.A.W. recommendations and state allowables represent the production of all petroleum liquids, including crude oil, condensate and natural gas derivatives recovered from oil, condensate and gas fields. Past records of production indicate, however, that certain wells may be incapable of producing the allowables granted, or may be limited by pipeline proration. Actual state production would, under such conditions, prove to be less than the allowables. The U. S. Bureau of Mines reported the daily average production of natural gasoline and allied products in September, 1942, as follows: Oklahoma, 30,200; Kansas, 5,100; Texas, 104,900; Louisiana, 20,500; Arkansas, 100; Wyoming, 2,400; Montana, 300; New Mexico, 6,000 California, 42,400.

[2]Oklahoma, Kansas, Nebraska, Mississippi, Indiana figures are for week ended 7 a. m., December 30

TRY THIS
effective treatment for paraffin problems

Paraffin is doubly troublesome these days. It restricts the flow of vital oil and it must be handled in a minimum of shut-down time with less available manpower. Chemistry, however, provides the most logical and timely answer —Dowell Paraffin Solvents.

Dowell Paraffin Solvents dissolve the paraffin and provide efficient and economical paraffin removal . . . the chemical treatment requires a minimum of physical labor; downtime is reduced to an absolute minimum and clean-out tools are not required.

Paraffin deposits often vary in composition and require many different solvent mixtures and treating techniques. Dowell's many years of experience in the chemical field will be of help to you in selecting the proper solvent and treating method.

Dowell Paraffin Solvents are stocked by numerous field supply stores, as well as all Dowell treating stations.

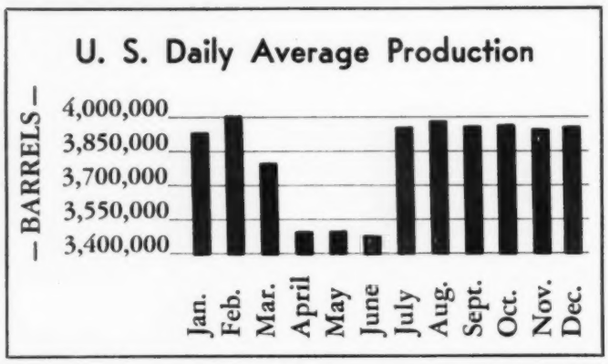
DOWELL INCORPORATED
Executive Office: Midland, Michigan
General Office: Kennedy Building, Tulsa, Oklahoma
Subsidiary of The Dow Chemical Company

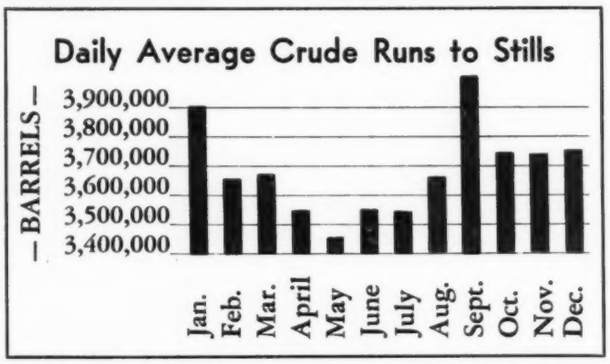
Look to

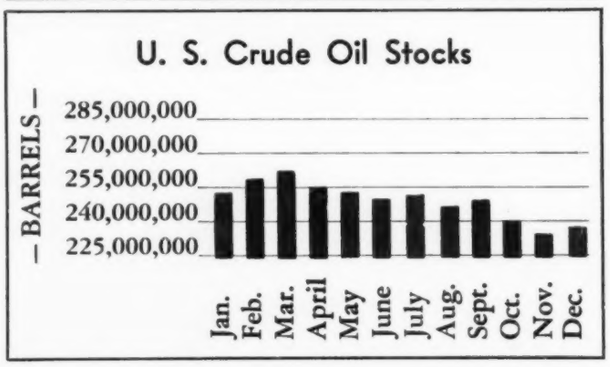
DOWELL

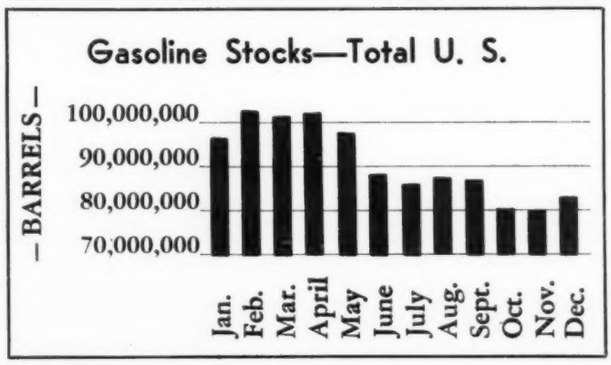
FOR OIL AND GAS WELL CHEMICAL SERVICE

PETROLEUM *Statistics* AND FIELD *Operations*









Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for December, 1942

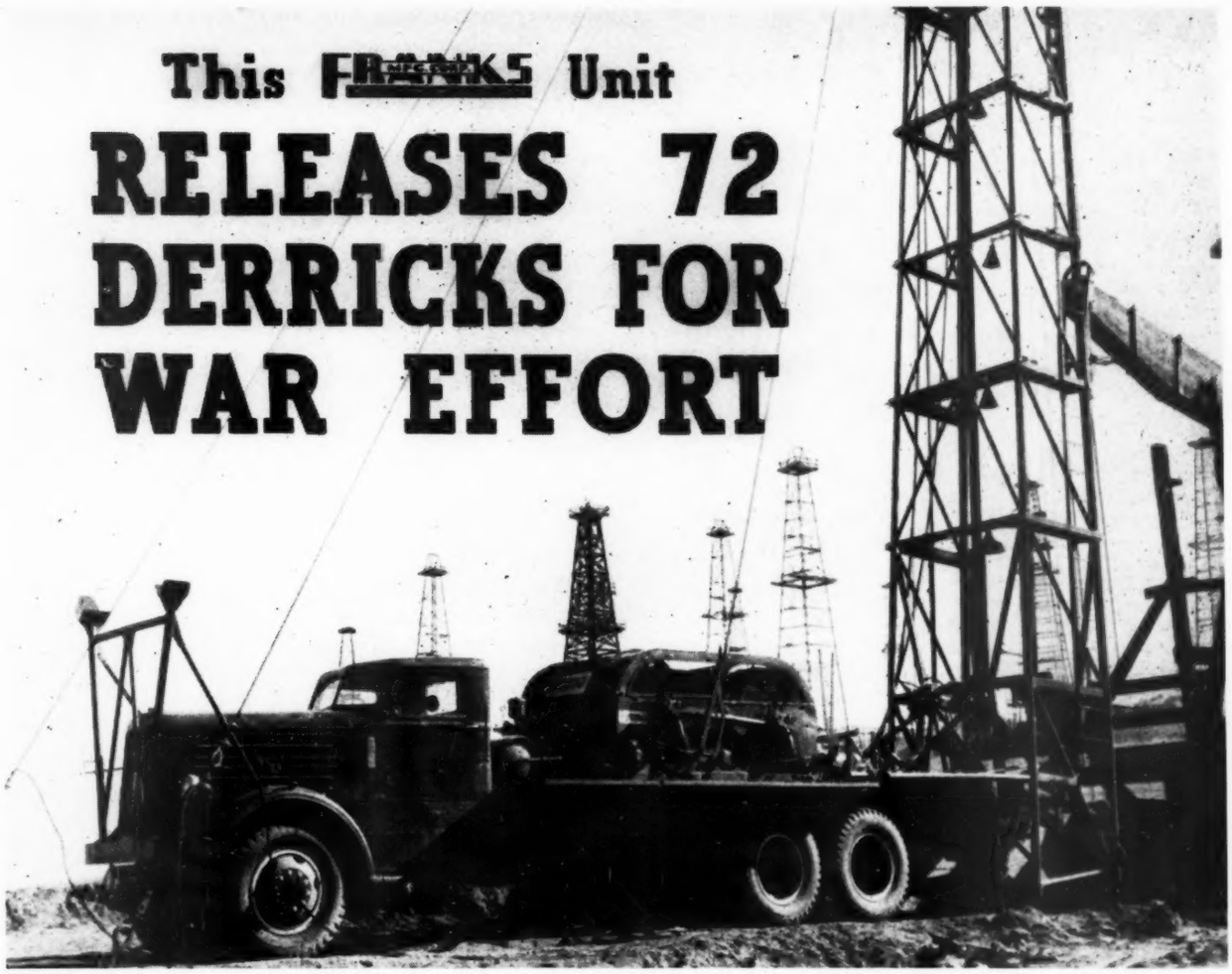
Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	33	25	3	....	3500-3700	2	40	Rotary
Gaines County	3	1	5	....	4400-5584	2	22-35	Rotary
Hockley County	9	7	3	....	4800-6850	2	20-30	Rotary
Ector County	4	2	5	....	3675-4377	2 or 3	32-36	Rotary
Panhandle	26	22	4	....	1700-3900	2	40	Rot.-Cab.
Nueces County	7	4	6	....	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	8	5	4	....	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	15	11	5	....	4495-4912	2	19-29	Rotary
OKLAHOMA								
Okfuskee County	4	2	7	4	2150-4125	2 or 3	38	Rotary
KANSAS								
Russell County	14	11	6	....	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	3	1	5	....	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	11	8	2	....	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	175	155	79	138	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	19	16	5	5	3150-4030	2	30-34	Rot.-Cab.
CALIFORNIA								
Kern County	4	3	4	1	1840-11,450	3 or 4	14-30	Rotary
Wilmington County	3	1	3	1	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for December, 1942

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1941 (In Barrels)
	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	Dec.	Nov.	
Arkansas	16	16	13	11	11	9	4	3	11	10	29,263,000
California	47	38	41	31	20	23	29	62	27	106	230,271,000
Illinois	175	168	155	158	52	46	58	79	138	131	131,272,000
Indiana	28	25	25	19	18	15	3	4	12	14	6,998,000
Kansas	127	136	120	127	62	66	16	9	25	38	82,733,000
Kentucky	8	1	5	1	3	1	....	....	....	....	4,790,000
Louisiana	186	173	177	162	50	55	15	8	16	9	116,038,000
Michigan	28	24	22	18	7	10	12	6	5	7	16,312,000
Mississippi	3	3	1	1	....	....	....	....	....	....	15,528,000
Montana	11	5	7	3	....	....	....	....	....	....	7,440,000
Nebraska	3	3	1	2	4	4	....	....	....	....	1,785,000
New Mexico	49	39	44	37	31	30	....	....	....	....	39,109,000
New York	73*	56*	64*	50*	51	47	....	....	....	....	5,180,000
Ohio	46	36	39	30	30	21	....	....	....	....	3,342,000
Oklahoma	143	104	128	96	28	25	3	5	77	55	154,817,000
Pennsylvania	109*	103*	101*	99*	119	79	....	....	....	....	16,700,000
Texas	493	427	418	400	331	290	325	348	340	309	501,745,000
West Virginia	31	27	26	21	10	12	4	5	11	4	3,418,000
Wyoming	2	....	1	....	3	....	2	....	2	....	29,952,000
Total	1578	1384	1388	1266	499	733	471	529	680	683	1,398,485,000

*Includes water-intake and pressure wells.

This FRANKS Unit RELEASES 72 DERRICKS FOR WAR EFFORT



Franks Servicing Units are NOW Serving the War Effort . . . . And They Will Be Better Than Ever When Peace Comes

The above Franks 200,000 lb., 90 ft. telescoping derrick servicing unit, shown on location in California, is replacing approximately 72 derricks — releasing considerable steel for war purposes. And each Franks truck-mounted 100% portable telescoping derrick servicing unit now in use or to be placed in service, will eliminate both the cost of and need for 50 to 100 permanent derricks.

As wells are being placed on the pump, Franks portable units are *not only* the most economical for servicing operations, but they *save* tons of steel in derricks (and crown blocks where the practice is to use individual blocks); *save* in labor since they require only backing into location, raising of the derrick by a patented mechanical screw device in seven to ten minutes (lines and blocks are carried strung) before pulling operations are begun.

Franks servicing units may be secured with a detachable derrick, which, after being raised, may be easily unhooked and left standing with pipe or rods stacked while the truck and winch are used elsewhere. Or, the derrick may be used with a skid work over unit. When the telescoping derrick is folded down over the truck, the units are within highway limits for length and width.

Franks various models of truck-mounted telescoping derrick units are available in capacities from 60,000 to 200,000 lbs. gross, with derricks up to 96 ft. when fully extended. See Composite Catalog or write Franks for complete details.

Franks is now serving in the war effort, but can supply your needs upon proper priority. Our experience in making war materials is enabling us to design an even better servicing unit and portable drilling rig.

FRANKS MFG. CORP.
WELL SERVICING AND DRILLING UNITS
Tulsa, Oklahoma

MAJOR *Pipe Line* ACTIVITIES

SIX barges carrying 2,100,000 gal. of fuel oil were last reported by Gulf Oil Corporation as en route to Cincinnati, Ohio, and expected to arrive within a few days. Other shipments are in transit. This fuel oil originated in the Port Arthur, Texas, refinery of the company and was then pumped by pipe line (through the newly completed war emergency pipe line, Project 5) to Helena, Arkansas. The barges were loaded at Helena on the Mississippi River.

Construction of the 857-mile eastward extension of the 24-in. War Emergency Pipeline from Norris City, Illinois, to refineries at New York and Philadelphia, was begun the latter part of December on the main line section west of Phoenixville Junction, Pennsylvania, Petroleum Administrator for War Harold L. Ickes has announced.

"In the language of the pipeliners, the first crew to 'set in' on the extension, 'kicked off' the moment they received clearance on the right-of-way." A second and third crew began work, and in early January work was going full blast on all 17 contract sections.

Deputy Petroleum Administrator Ralph K. Davies said that more than 160 miles of 24-in. pipe for the extension had already been delivered to distribution points along the right-of-way at the time the announcement was made, and that if pumping and terminal equipment could be obtained according to schedule the 1388-mile Texas-East Coast pipe line would begin initial deliveries of crude and fuel oils to eastern terminals by midsummer. Laying the Texas-Illinois leg of the line was begun last August.

"Advance deliveries of pipe for the extension are indicative of the speed we hope to be able to maintain on the eastward leg of the War Emergency Pipeline," Davies said.

"Seventeen experienced construction crews will push the line eastward right through the winter, and despite the hazards and delays to be expected during the winter months, the line should be sufficiently advanced by spring to insure on-schedule completion. The availability of pumping, terminal, and oil storage equipment will determine the exact date of initial operation of the extension."

PAW pipe-line officials stated that more than 400 railroad cars were required to move the giant ditchers, tractors, trucks, and welding and pipe-processing equipment necessary to build the Illinois-East Coast leg of the longest, largest oil-carrying pipe-line in the world.

When completed for full operation, the "big inch" will deliver 300,000 bbl. of crude or fuel oils daily to East Coast terminals. Twenty-five pumping stations along the 1388-mile route will be required to move the stream of oil from Texas oil fields and refineries to the East Coast terminals.

According to Davies, the extent to which the added delivery of the 24-in. line may alleviate the critical Eastern oil shortage will depend largely on the development of Army-Navy demands for off-shore shipment to the theaters of war.

Flood waters washed out 600 ft. of the 24-in. War Emergency Pipeline crossing of the Mississippi River to delay the date of initial shipments through the Texas-Illinois leg of the pipe line.

The Petroleum Administrator received word of the damage in a telegraphic report from Burt E. Hull, vice-president of War Emergency Pipelines, Inc. The wire read:

"Construction Mississippi River crossing was well advanced and completion expected December 30, but river began rising rapidly Monday. Suspended work and all available steel cable and additional anchorage attached to pipe but river rose 15 ft. and rapid current broke several cables and about 600 ft. off free end of pipe at four o'clock Tuesday morning. Apparently no serious damage to barges and other floating equipment. We are diverting to Mississippi River shipments sufficient amount extra heavy pipe, anchors, and other materials now enroute other river crossings Indiana and Ohio. Assuming river will fall enough to resume work by January 10. Believe we can install and complete new crossing by January 25 because very deep trench through rock section in river bed is still open and about 400 ft. pipe and anchorage on west end of crossing is undamaged. Total length crossing 2600 ft. Will not undertake salvage materials in present crossing until new crossing finished. Regrets.

"War Emergency Pipelines, Inc.,
B. E. Hull."

Commenting on the delay, Petroleum Administrator for War Harold L. Ickes said:

"We had reasonable expectations that crude and fuel oils would be flowing through the line between Longview, Texas, and Norris City, Illinois, at the end of January. Now, under the most favorable conditions it is improbable that the Mississippi River crossing can be repaired and completed prior to January 25, and continued high-water conditions might hold up completion beyond the date. The probable date of initial deliveries at the Norris City terminus of the pipe line must be postponed from the end of January at least three weeks as a result of this flood.

"I have instructed War Emergency Pipelines, Inc., to spare no effort that will assist the earliest possible repair and completion of this important link in the 24-in. pipelines."

The 531-mile stretch of the pipe line between Longview, Texas, and Norris City, Illinois, will, when in full operation, make possible a net increase of 120,000 bbl. per day in East Coast deliveries of crude and fuel oils. Upon completion of the eastern extension of the line from Norris City, about June 1, 1943, deliveries to the East Coast through the line will be 300,000 bbl. per day.

The Defense Plant Corporation has authorized an expenditure of $102,850,000 for construction of four pipe lines to transport petroleum products from Texas and the Middle West. This information was contained in a report made on the activities of the Reconstruction Finance Corporation and its subsidiaries by Jesse H. Jones, secretary of commerce.

In the report it was stated: "A 24-in. line is planned to extend from Longview, Texas, to Salem, Illinois, a distance of 530 miles, at an estimated cost of $35,000,000. This line is now being continued to Philadelphia, Pennsylvania, and New York, an additional distance of 857 miles, at an additional cost estimated at $60,000,000.

An 8-in. line across northern Florida, a distance of 198 miles, at a cost of $3,000,000. An 8-in. line from Greensboro, North Carolina, to Richmond, Virginia, a distance of 175 miles, at a cost of $3,600,000, to connect with existing systems from Texas.

"An 8-in. line from Fostoria to Akron, Ohio, a distance of 82 miles, at a cost of $1,250,000 to connect with existing Ohio lines that terminate at Philadelphia and Newark, New Jersey.

"The last three mentioned lines will be built principally from second-hand reconditioned materials and facilities. Other pipe lines may be necessary."

P 989.1

THE Petroleum Engineer

JANUARY, 1943

1943 May Be Critical Year for Petroleum

Exclusive

☆ **Decline in crude oil reserves remains unchecked—Present allocations of steel for drilling pitifully inadequate and, in view of steadily mounting war demands, grossly incommensurate with oil's importance in war—More steel and higher crude oil prices needed to stimulate exploration and drilling activity**

by K. C. Sclater

Editor

THE petroleum industry shoulders the greatest responsibilities in its history, responsibilities that will increase in gravity during 1943. War requirements are mounting rapidly. The armed forces, war industries, and essential civilian needs must be kept adequately supplied with fuel, lubricants, and other vital petroleum products. At the same time, raw materials for synthetic rubber and explosives must be provided.

If, as we are given to understand by military authorities, this will be a long war—and there is no reason to doubt that it won't be—that fact should be faced. No matter how long the war lasts, whether two or five years, every effort should be made to insure that supplies of petroleum and its products will be adequate for all war needs without impairing our existing available reserves. To achieve this objective, the drilling and producing branches of the industry are facing a formidable task. A precious year of time has passed since we entered the war and our failures to uncover new oil reserves continue at an increasingly greater pace.

Our present oil reserves in this country are estimated at somewhat less than 19 million barrels.[1] This estimate assumes that fields will be produced at their optimum rate. When fields are produced at a rate greater than their optimum, they suffer a loss in the amount of oil that can be recovered.

During 1942 nine times as many dry holes as in 1935 were drilled per million barrels of oil discovered. The cost per barrel of new oil reserves has increased from 6½ cents in 1937 to almost 38 cents in 1942. This increase in cost was reasonably steady from 1937 to 1941, during which period the yearly average was about 3½ cents per barrel, but in 1942 the cost per barrel rose 18 cents to almost 38 cents, or five times the average cost per barrel of the preceding four-year period.

The demand for crude in 1942 was stimulated artificially as a direct result of reducing refinery yields of gasoline.[1] The increase in crude requirements during December due to decreasing the yield of gasoline and augmenting production of heavy fuel was 700,000 bbl., or 22 percent. For January of this year, the added requirement due to the low gasoline yield will be 25 percent. In other words, to meet war requirements, refiners are sacrificing efficiency by reducing gasoline yield and supplying heavy fuel. As a result, refiners are suffering heavy financial losses that threaten to force many of them out of business.

The wildcatting program of 1942 has fallen lamentably short in finding

[1] "Study Reveals Imperative Need for Increasing Nation's Oil Reserves," by H. J. Struth, on p. 31 of this issue.

new available supplies of oil. New reserves discovered last year are only a fraction of what they should have been to meet future essential war needs. The volume of oil produced was five times greater than the new reserves discovered.

Although the number of wildcats drilled in 1942 was about the same as that drilled in 1941, the total number of wells drilled in 1942 was only sixty percent of the total drilled in 1941. Manifestly, more wells must be drilled this year than last, particularly wildcat wells, to maintain the nation's oil reserves at a safe level. The Director of Production in the Office of the P.A.W. has said that we must drill at least 4500 wildcat wells during 1943, and even more if that is necessary. As for the total number of wells to be drilled, no information is available. It may be somewhere between 18,000 and 20,000, depending on the quantity of materials allocated to the industry.

To make wildcat drilling more effective and reduce the percentage of dry holes, more than likely a "certificate of necessity" will be required to drill a well. The object would be to discourage random drilling, such as wildcatting in areas where the oil possibilities are not too favorable, or where the oil, if found, is of an undesirable grade, or where transportation facilities are lacking, or in areas remote from refining and shipping centers.

A "sure-fire" method of locating oil from the surface has not yet been developed. The best we have been able to do is to locate favorable or promising areas for discovering oil. The oil, if present, is found only by drilling. No matter what exploratory methods are followed, the drill provides the tangible evidence of the presence of oil. The elements of chance still enters largely into the dicovery of new reserves of oil. It therefore takes time, an indefinite time, to discover new fields.

Despite the important part petroleum is playing in the war now raging, the petroleum industry has been denied sufficient critical materials to undertake an intensive drilling campaign of the scope necessary to insure adequate supplies of oil being available should the war last for two or more years. Instead of receiving encouragement, the industry has had obstacles placed in its path and has been hampered by restrictions. Giving due regard to the tremendous problems that the country is facing and the efforts being made by all units of the industry to prosecute the war as efficiently as possible, it confounds many oilmen why the needs of the petroleum industry have been brushed aside by certain governmental bureaus. The Petroleum Administrator for War and his staff have had to and still continue to wage a valiant effort to obtain sufficient materials for only the very barest needs, although the need for the oil industry to step-up its program of exploration and production is immediate and imperative.

As long ago as October, 1942, Congressman Cole reported[2] to the President and warned of the seriousness of the situation with respect to the nation's crude oil reserves, when he said, "There is a serious lack of understanding among both officials and laymen as to the real situation with respect to the supply of petroleum products for the conduct of the war. They have heard about the estimated eighteen to twenty billions of barrels of crude petroleum remaining in the oil fields of this country and have the idea that this is a 13 or 14 years' supply at our present rate of consumption.

"There is no justification for such a belief. It will take many more than 14 years for this oil to be produced. Some of this oil will not be produced for 50 years.

"With our present transportation and present rate of discovery, showing any regard for conservation, we will be short of oil within two years."

Materials and manpower shortages have beset the industry and are growing more acute. As production in 1943 is expected to be the greatest in the history of the industry, the need for concentrating on the war effort is apparent. If the industry is to fulfill its function and render fullest aid to the war effort, continual threats to eliminate depletion allowances and make other changes in the industry's basic economy should be removed. It has been stated that the oil industry realizes it is entitled to no more materials than are absolutely essential to perform what the nation expects of it, but in many instances it is felt that there has been a failure to understand the industry's minimum needs. Petroleum Administrator Ickes may be able to remove misconceptions that have led to this attitude on the part of official Washington.

Faced with the prospect of reverting to wasteful methods of production, oilmen are prompted to ask: Why hasn't the petroleum industry been allocated more steel and other critical materials? As highly essential as oil is in war, the scant consideration that the producing branch of the industry has received at the hands of certain government bureaus is incomprehensible. It has puzzled oil men. How essential is petroleum, and just how essential is it in war compared with other critical materials? It is stated on good authority[2] that two-thirds by weight of all material shipped to the battle front is petroleum. That may be a startling statement, but it is true. It leaves no room for argument regarding how essential petroleum is in war. But what about the quantity and availability of the nation's petroleum supply? On the answer to this question hinges the decision of Washington authorities whether enough steel should be made available for finding and producing oil. There is plenty of factual evidence[1] that our oil reserves are dwindling rapidly and not being replenished.

The Petroleum Subcommittee of the House Committee on Interstate and Foreign Commerce has recommended the removal of handicaps to increase production and that steps be taken to give the industry more skilled manpower, an increase in the price of crude, eliminate government threats to terminate depletion allowances, greater supplies of steel and other production materials. This Committee even goes so far as to anticipate that war needs may reach one million barrels more daily than is now being produced. This Committee believes that wasteful methods of production should not be resorted to in the producing fields of the United States. It even suggests that steps be taken to obtain more oil abroad in addition to bringing in new domestic fields.

When a field is required to produce beyond its optimum rate, efficient production methods are cast aside, underground waste occurs, and a loss in valuable recoverable oil reserves results. More steel must be allocated, an increase in crude price granted to stimulate wildcat drilling, and manpower made available, to meet the present emergency and avoid loss of existing oil reserves.

In addition to being granted an increase in the price of crude, the industry is justified in insisting on a larger apportionment of steel and other critical materials to carry on drilling and producing operations. In the interest of national security, and considering that petroleum makes up two-thirds of the total weight of material shipped to the battle front, and in view of declining oil reserves and impending shortages of petroleum, the dire consequences that may ensue should be brought home to governmental authorities. All signs point to the year 1943 being a critical one in which the facilities of the oil industry will be taxed to the utmost to fill the increasing demands of war.

☆ ☆ ☆

[2]"Letter to President Roosevelt on Petroleum Under War Conditions," by Hon. William P. Cole, Jr., of Maryland, on his retirement as Chairman of the Petroleum Subcommittee of the Committee on Interstate and Foreign Commerce, in the House of Representatives, October 22, 1942. (See Congressional Record, Thursday, October 22, 1942.)

Study Reveals Imperative Need for Increasing Nation's Oil Reserves

PETROLEUM ENGINEER Exclusive Feature

☆ **Serious depletion of U. S. oil reserves due to greater than normal withdrawals from surface and underground inventories and continuing lag in new discoveries—Reduced gasoline recovery led to increased demand for crude oil in 1942**

by H. J. Struth

Petroleum Economist

H. J. STRUTH

has for many years been identified with the petroleum industry as one of its leading economists—His intimate knowledge of the petroleum situation is founded upon his early training in the oil fields, refineries, and the oil laboratory—He is a member of the A.I.M.E. and resides in Dallas, Texas, where he is economist for the Texas Mid-Continent Oil and Gas Association.

CRUDE oil production in 1942 was a little more than 1 percent less than in 1941, whereas runs to refinery stills showed a decline of less than 5 percent. With gasoline consumption off nearly 10 percent from 1941, as a result of voluntary curtailment of driving by motorists and the imposition of gasoline rationing, this seems at first to be somewhat surprising.

Figures show that the demand for crude oil in 1942 was artificially stimulated to about 12 percent above 1941, as a direct result of reducing refinery yields of gasoline to the extent of about 5 percent. It is apparent, therefore, that the demand for crude oil in 1942 was about 145,000,000 bbl. greater than it would have been under conditions prevailing in 1941.

Crude Demand Greater

The crude oil demand outlook for this year presents a picture that may tax existing production facilities of the industry. Despite curtailment in civilian use of gasoline, oil requirements for war and for the relief of fuel oil users in the northeastern states will call for the production of at least 1,475,000,000 bbl. of crude oil this year, compared with 1,385,000,000 bbl. in 1942. Under the present program of producing less gasoline and more fuel oil, coupled with an increased demand for war products, it is likely that crude oil production schedules this year will in many instances prove contrary to the industry's accepted production practices for the prevention of physical and economic waste.

An idea of the demand for crude oil the petroleum industry faces this year may be gleaned by examining the refining statistics for December, 1942, and comparing them with the same month of 1941. Refinery crude demand in December, 1942, was about 115,000,000 bbl. for the production of about 43,000,000 bbl. of straight run and cracked gasoline, a yield of 37 percent. In December, 1941, refinery crude runs were nearly 125,000,000 bbl. for the production of 57,000,000 bbl. of gasoline, which represents an average yield of 45.7 percent. On the basis of yields obtained in December, 1941, the current crude requirement would have been only 94,000,000 bbl. instead of 115,000,000 bbl. The difference of 21,000,000 bbl. represents an actual gain in crude requirements of 22 percent above normal and therefore calls for an increase in supply of nearly 700,000 bbl. more a day than would ordinarily have been needed.

Analysis of the immediate supply and demand situation makes it evident

TABLE I

Salient facts of the United States crude oil situation

Annual averages—1916 through 1942

	1916 1920	1921 1925	1926 1930	1931 1935	1936 1940	1941 1942
New supply (millions)	412	743	963	928	1,274	1,442
Total demand (millions)	413	706	950	946	1,282	1,461
Stock changes:						
Increase (millions)	....	37	....	....	....	....
Decrease (millions)	1	....	13	18	8	19
Average posted price	$2.07	$1.54	$1.34	$0.83	$1.09	$1.14
Wells drilled	27,359	23,635	24,678	15,880	27,589	25,130
Dry holes drilled	5,571	5,631	7,380	3,953	6,147	6,331
Percent dry holes	20.4	23.7	29.9	24.9	22.3	25.2
Reserves discovered (millions)	660	970	2,840	1,200	1,303	445
New reserves found per dry hole (thousands)	118	172	385	303	210	60
Surplus or shortage in discoveries (millions)	+247	+264	+1,890	+254	+21	—1,016

"Peaks" compared with year 1942

Peak year		Peak	1942
1920	Wells completed	33,911	18,120
1920	Price of crude oil	$3.07	$1.17
1922	Stock increase	88 million bbl.	Decrease 17 million bbl.
1926	Dry holes drilled	7,965	5,543
1930	New reserves found	5,600 million bbl.	275 million bbl.
1941	Crude oil production	1,404 million bbl.	1,385 million bbl.
1941	Crude oil demand	1,475 million bbl.	1,440 million bbl.

that the petroleum industry is not only failing to find new oil in sufficient quantities to offset heavy withdrawals from underground reserves, but is actually using its available supplies 22 percent faster than the efficient rate of utilization realized under peace-time conditions. In other words, for every 100,000,000 bbl. of oil needed in 1941, 122,000,000 bbl. are now needed to produce relatively the same quantity of products, without considering additional demands being created by our prosecution of the war.

A factor of far-reaching importance to the adequacy of the nation's known oil reserves and new discoveries has been the remarkable scientific advancement in the refining of petroleum; making one barrel accomplish what two barrels did in the last world war. Under the paradox lately created by the contraposition of gasoline and fuel oil, however, the nation's declining reserves and lagging discoveries are particularly disturbing.

The situation created by the shortage of fuel oil can and will be corrected in due course of time. Meanwhile, however, the demand outlook for petroleum products, particularly from our armed forces, which are rapidly spreading to all parts of the world, prompts immediate and serious consideration of ways and means to promote a more intensive search for new sources of oil supply.

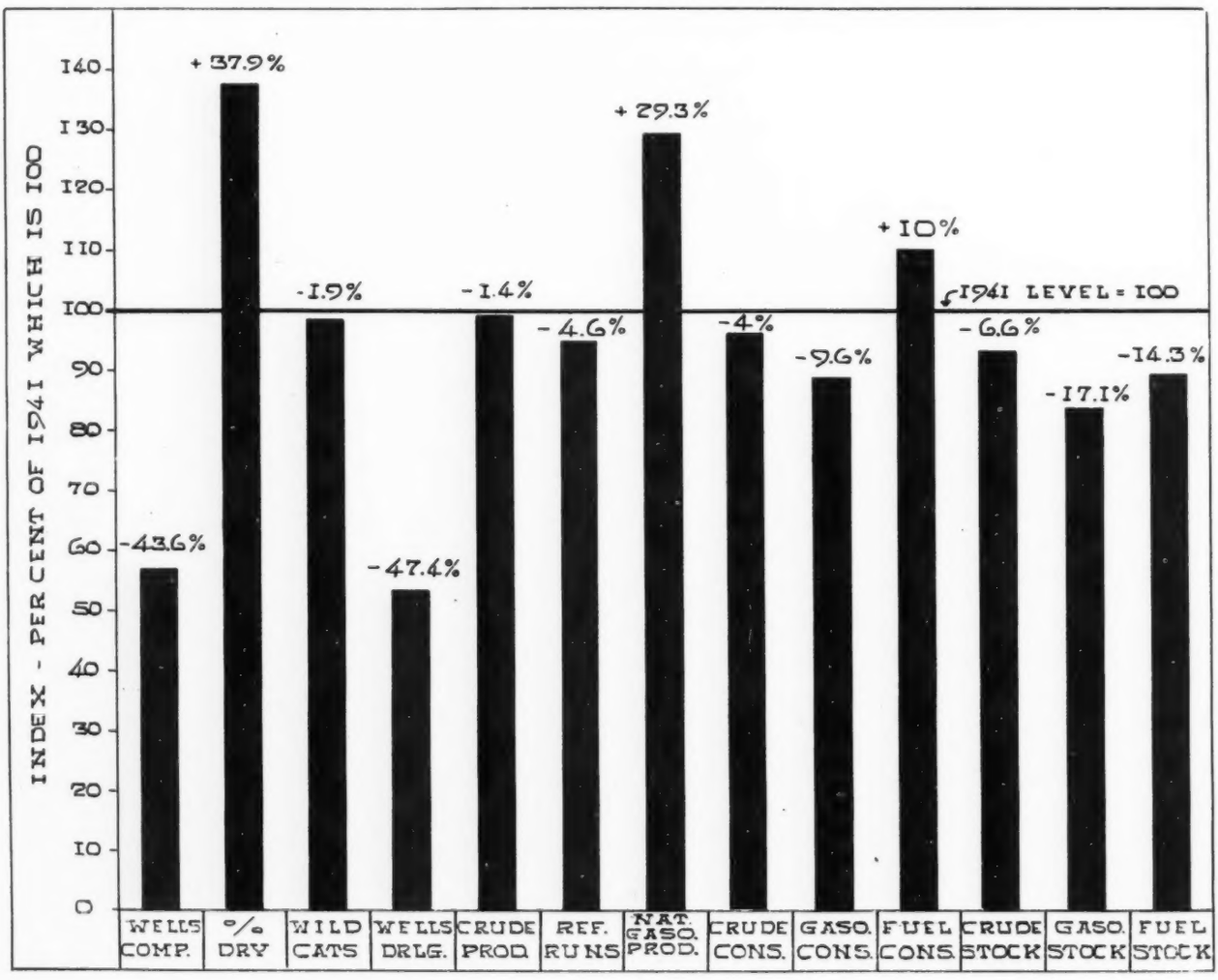
Discoveries 55 Percent of Production

When the fact is considered that the nation's petroleum reserves have declined since 1938 to the extent of more than 3,000,000,000 bbl. and the further fact that new discoveries including extensions in 1942 comprised only about 55 percent of the year's production, it is difficult to view the immediate future with any degree of confidence. The nation's petroleum reserve situation has reached a serious stage and unless drastic steps are taken to augment growing withdrawals with new sources of supply, the possibility of being unable to produce near-future requirements must be faced. Contrary to opinions shared by some oilmen, the writer believes that great difficulty will be experienced in meeting an increased production quota of, say, 400,000 bbl. of oil a day from existing producing areas of the nation. To do so would undoubtedly strain existing producing facilities and contribute to premature decline in productivity of many oil fields.

Drilling activity and results therefrom were far from being satisfactory in 1942. With the difficulty experienced in obtaining equipment under the now almost obsolete War Production Board order M-68, and the constantly increasing cost of drilling exploratory wells,

Fig. 1. United States petroleum situation—Year 1942 compared with 1941

Columns are relative to heavy horizontal line (100), which represents level of each factor during the year 1941. Percentages show increase or decrease in 1942 compared with 1941. Details are presented in Table 2



the number of well completions showed a decline of nearly 44 percent from 1941. At the same time, despite a greater concentration on wildcat operations than upon routine drilling, the percentage of dry holes increased from an average of 22.2 to 30.6. Relatively, this is an increase over 1941 of nearly 38 percent, as will be noted in the Petroleum Situation chart, Fig. 1. Wildcat drilling was practically at the same level in 1942 as in 1941, the total number of wells showing a decline of less than 2 percent. Compared with 1941, routine drilling was off to the extent of nearly 14,000 wells, a 48 percent drop.

TABLE 2

Year 1942 compared with years 1940 and 1941

	1940	1941	1942°	Index '41–100	Percent change
Total wells drilled	28,094	32,140	18,120	56.4	—43.6
Oil wells	19,125	22,005	10,473	47.6	—52.4
Gas wells	2,352	3,014	2,104	69.8	—30.2
Dry holes	6,617	7,121	5,543	77.8	—22.2
Percent dry	23.6	22.2	30.6	137.9	+37.9*
Wildcat wells drilled§	2,862‡	3,160	3,100	98.1	— 1.9
Wildcat producers	415‡	460	442	96.1	— 3.9
Percent dry	84.0‡	83.6	83.9	100.3	+ 0.3
Wells drilling, Dec. 31	3,228	3,998	2,157	52.6	—47.4
Crude production (thousands)	1,353,214	1,404,182	1,385,000	98.6	— 1.4
Daily average (thousands)	3,697	3,847	3,795	....	....
Refinery runs (thousands)	1,294,162	1,409,192	1,340,000	95.4	— 4.6
Daily average	3,536	3,861	3,671	....	....
Natural gasoline production (thousands)	55,700	64,204	83,000	129.3	+29.3
Daily average (thousands)	152	176	227	....	....
Crude oil demand† (thousands)	1,372,569	1,473,710	1,415,000	96.0	— 4.0
Daily average (thousands)	3,750	4,038	3,877	....	....
Gasoline demand (thousands)	614,867	686,973	621,098	90.4	— 9.6
Daily average (thousands)	1,680	1,882	1,701	....	....
Fuel oil demand (thousands)	536,263	546,149	600,112	110.0	+10.0
Daily average (thousands)	1,465	1,496	1,644	....	....
Crude oil stocks (thousands):					
January 1	253,308	276,615	257,063	92.9	— 7.1
December 31	276,615	257,063	240,000	93.4	— 6.6
Change	+23,307	—19,552	—17,063	....	....
Day's supply, December 31	74	63	62	....	....
Motor fuel stocks (thousands):					
January 1	82,865	90,113	94,098	104.4	+ 4.4
December 31	84,649	94,098	78,000	82.9	—17.1
Change	+ 1,784	+ 3,985	—16,098	....	....
Day's supply, December 31	50	50	45	....	....
Fuel oil stocks (thousands):					
January 1	126,008	132,244	133,121	100.7	+ 0.7
December 31	132,244	133,121	114,000	85.7	—14.3
Change	+ 6,236	+ 877	—19,121	....	....
Day's supply, December 31	90	89	69	....	....
All refined stocks (thousands):					
January 1	268,109	282,265	290,375	102.9	+ 2.9
December 31	282,265	290,375	251,000	86.5	—13.5
Change	+14,156	+ 8,110	—39,375	....	....
Day's supply, December 31	81	78	69	....	....
Crude oil prices (December):					
Mid-Continent, 36 gravity	$1.02	$1.17	$1.17	100.0	0
East Texas	1.10	1.25	1.25	100.0	0
Pennsylvania, Bradford	2.15	2.75	3.00	109.1	+ 9.1
California, 26 Signal Hill	0.99	1.11	1.11	100.0	0
Refinery Product prices (December):					
Motor gasoline, group 3	4½	6	5⅞	97.8	— 2.2
Motor gasoline, New York	5½	8	9.2	115.0	+15.0
Motor gasoline, Gulf	3½	6¼	5¾	92.0	— 8.0
Motor gasoline, California	4½	5½	5½	100.0	0
Kerosine, 41-43, group 3	4	4¾	4⅞	100.0	0
Kerosine, New York	5.3	5.3	6.8	128.3	+28.3
Furnace oil, group 3	3⅝	3⅝	3½	103.9	+ 3.9
Bunker C. fuel, New York	$1.15	$1.45	$1.65	113.8	+13.8
Natural gasoline, group 3	2⅝	5⅛	3⅞	75.6	—24.4
Natural gasoline, California	4½	4½	4¾	105.6	+ 5.6

°Preliminary—subject to final revision.
†Does not include aviation gasoline.
‡Estimated.
*Relative increase—actual percentage increase 8.4 percent.
§Included in total wells shown above.

More Wildcats in Prospect

A check of the number of wells drilling on December 31, showed that there were only about 2157 new operations, compared with 3998 at the close of 1941, a decrease of more than 47 percent. The immediate outlook calls for less routine drilling this year and an increase in wildcat operations from 3100 wells to 4500.

Table 2 presents a preliminary summary of the oil industry's basic statistics for 1942, with comparisons for 1940 and 1941. The more important changes recorded therein are presented graphically in Fig. 1, which shows the percentage changes in 1942 compared with 1941. It will be noted that the decline in gasoline consumption was practically offset by the increase in demand for fuel oil. Significant with respect to heavy withdrawals from underground inventories was the sharp reduction in aboveground stocks of crude oil as well as reductions recorded in stocks of gasoline and fuel oil.

Demand 3½ Times Greater Than Last War

Table 1 presents some interesting comparisons from 1916 through 1942. Of particular significance is the rise in average annual demand for crude oil from 413,000,000 bbl. in 1916-20 to 1,461,000,000 bbl. in 1941-42. The peak demand was in 1941, with a total of 1,475,000,000 bbl. It will be noted that the demand for oil has increased 3½ times since the last world war period. In the last world war period the industry only withdrew from storage an average of 1,000,000 bbl of crude a year, whereas in the present war period we have withdrawn an average of 19,000,000 bbl. a year from storage.

Crude oil prices are 45 percent below the levels that prevailed in the last world war. During the first world war the industry found an average of 247,000,000 bbl. of new reserves above production requirements, whereas in the present war period new reserve discoveries are short of actual needs by 1,016,000,000 bbl. a year. In the first world war 118,000 bbl. of oil were discovered per dry hole drilled, but in the present war period the average is only 60,000 bbl. per dry hole, and for the year just ended the average was 49,000 bbl. per dry hole.

The number of dry holes drilled in 1942 was only 30 percent below the peak established in 1926, although the total number of wells completed was about one-half of the completions recorded in the peak year of 1920. Significant, too, is the fact that last year's new reserve discoveries were less than 5 percent of the peak oil finding year

TABLE 3
United States crude oil situation

	1942°	1941	Change from 1941
Stocks, January 1	257,063,000	276,615,000	—19,552,000
Production	1,385,000,000	1,404,182,000	—19,182,000
Total	1,642,063,000	1,680,797,000	— 38,734,000
Refinery runs	1,340,000,000	1,409,192,000	—69,192,000
Used as fuel	37,000,000	30,482,000	+6,518,000
Stocks, December 31	240,000,000	257,063,000	—17,063,000
Total	1,617,000,000	1,696,737,000	—79,737,000
Balance of foreign trade*	+25,063,000	—15,940,000	—41,003,000

*Export and import figures are not available. This is balancing figure that represents approximate difference between exports and exports. The plus sign indicates an excess of exports over imports, whereas the minus sign indicates an excess of imports over exports.

°Preliminary—subject to final revision.

TABLE 4
Crude oil production of leading oil states
(In thousands of bbl.)

State	1942°		1941		Percent change
	Total	Daily	Total	Daily	
Texas	484,000	1,326	507,584	1,391	— 5
Louisiana	114,500	314	115,908	318	— 2
Oklahoma	141,190	387	154,759	424	— 9
Kansas	98,380	270	83,261	228	+18
California	248,000	679	230,263	631	+ 8
Illinois	106,500	292	134,138	368	— 21
Arkansas	27,080	74	26,327	72	+ 3
New Mexico	31,500	86	39,369	108	—20
Other states	133,850	367	112,573	307	+19
U. S. total	1,385,000	3,795	1,404,182	3,847	— 1

°Preliminary—subject to final revision.

of 1930, when East Texas came into the picture.

Crude Market Stationary

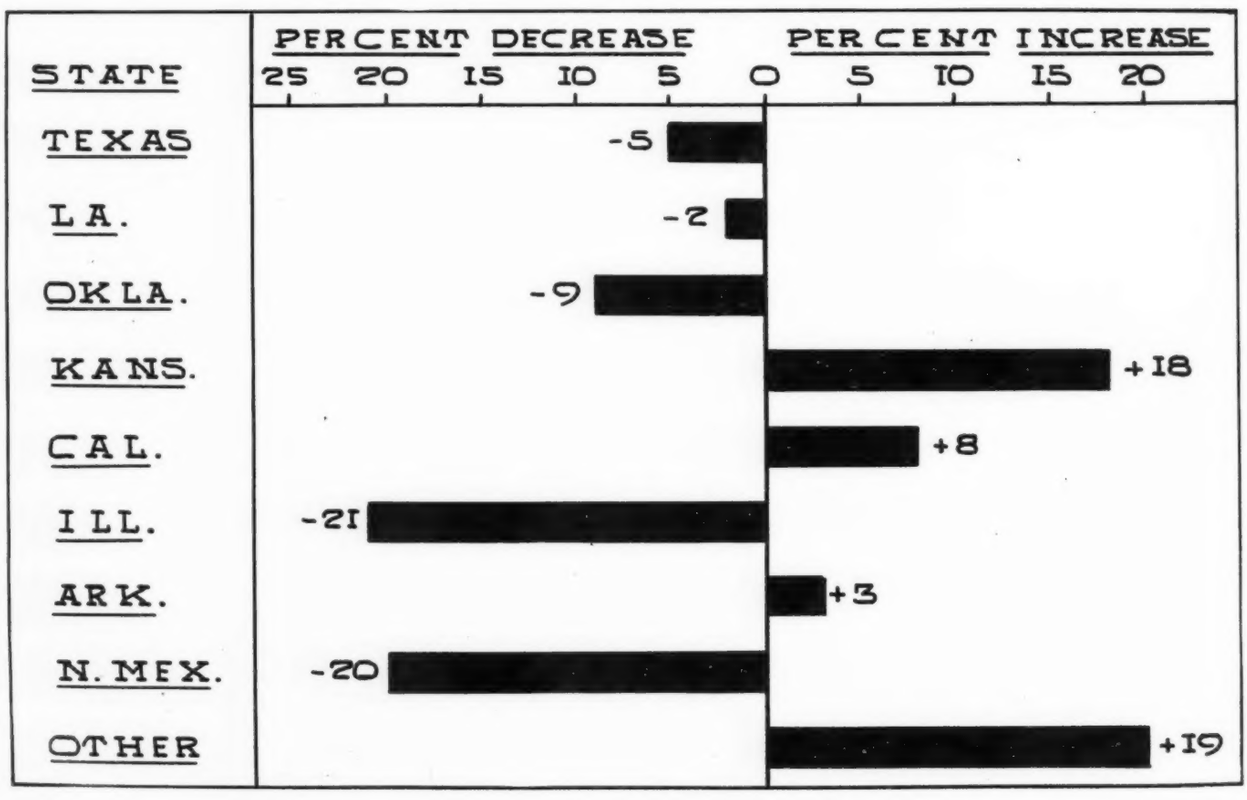
Crude oil prices were practically stationary in 1942, with the exception of Pennsylvania crude, which showed an advance over December, 1941, of 9 percent. Increases ranging from 3.9 percent to 28.3 percent were recorded in refinery product prices. Refinery gasoline prices were off 2.2 percent in Group 3 and 8 percent in the Gulf Coast, but the New York market showed an increase of 15 percent. Likewise, kerosine prices in Group 3 were unchanged, whereas the kerosine market in New York was up 28 percent. Natural gasoline prices in Group 3 were off 24 percent, whereas California naturals were advanced 5.6 percent. Bunker C fuel oil at New York Harbor was advanced nearly 14 percent to $1.65 per bbl. This represents an advance of 50 cents per bbl. since 1940.

Supply-Demand Data

Suspension of import and export statistics makes it difficult to analyze the actual supply and demand picture for crude oil. Table 3 presents available data on supply and demand for crude

Fig. 2. Changes in crude oil production in 1942 compared with 1941

Columns show percentage increase or decrease in crude oil production of states listed. Details are shown in Table 4



oil in 1942 and 1941 for comparative purposes. It will be noted that the difference between opening stocks and production and closing stocks and domestic demand results in a difference attributable to foreign trade balances. In 1942, it is apparent that there was an excess of exports, presumably to Canada, amounting to more than 25,000,000 bbl. In 1941 there was an apparent excess of imports over exports of nearly 16,000,000 bbl. Amounts shown as used as fuel include transfers from crude oil to fuel oil during both periods. The shortage of fuel oil in 1942 resulted in an increase in transfers from crude to fuel.

Although crude oil production of the nation showed a decline last year of 1 percent, some of the oil states showed increases of as much as 18 percent. Table 4 shows the crude oil production of leading oil states in 1942 and 1941 and the data are graphically presented in Fig. 2. Texas, Louisiana, Oklahoma, Illinois and New Mexico reported decreased production, whereas Kansas, California, Arkansas, and the Eastern States reported increased production. Illinois reported a decline in crude oil production of 28,000,000 bbl., whereas Texas crude output declined more than 23,000,000 bbl.

Pronounced Drilling Decline

Field operations were sharply curtailed last year in Texas, Louisiana, Oklahoma, and Illinois. Texas well completions declined 51 percent below 1941, followed by Illinois with a drop of 50 percent, Oklahoma 46 percent, and Louisiana 45 percent. The most pronounced declines in oil-well completions were reported in Illinois, with a decline of 61 percent and Oklahoma with a drop of 57 percent. As a result of decreased routine drilling and greater concentration on wildcat operations the percentage of dry holes showed a substantial increase. Table 5 and Fig. 3 show some pronounced changes in drilling operations last year in comparison with 1941. Dry hole percentages were sharply increased in Illinois, Oklahoma, Kansas, California, and Texas.

Greater concentration on wildcat drilling is anticipated in 1943. It is therefore significant to review the wildcat picture recorded in 1942. Fig. 4 shows where the wildcat wells were drilled in 1942. Texas led in the number of wildcat wells drilled, with approximately 35 percent of the nation's 3100 wildcats completed in 1942. Of all the wells completed in Texas last year 22 percent were wildcats. In 1941 only about 12 percent of Texas well completions were wildcats. This was responsible for materially higher drilling costs in Texas last year, as a majority of the wildcat operations were drilled to greater depths than have been recorded for normal routine operations.

Illinois wildcat operations constituted about 18 percent of the nation's total last year. About 30 percent of all the wells drilled in Illinois last year were wildcats. Kansas drilled about 12 percent of the nation's wildcats and 24 percent of all the wells drilled in that state last year were wildcat operations. Oklahoma drilled about 10 percent of the nation's wildcats and 26 percent of that state's drilling operations were in this classification.

Wildcats comprised only about 15 percent of all the wells drilled in California, which contributed 4 percent of the wildcats drilled in the United States. California's reserve situation is far from

Fig. 3. Comparative field operations for 1942 and 1941

The effect of restricted drilling operations is reflected by the sharp decreases recorded in well completions and particularly the greater loss ratios in dry hole drilling. Details are shown in Table 5

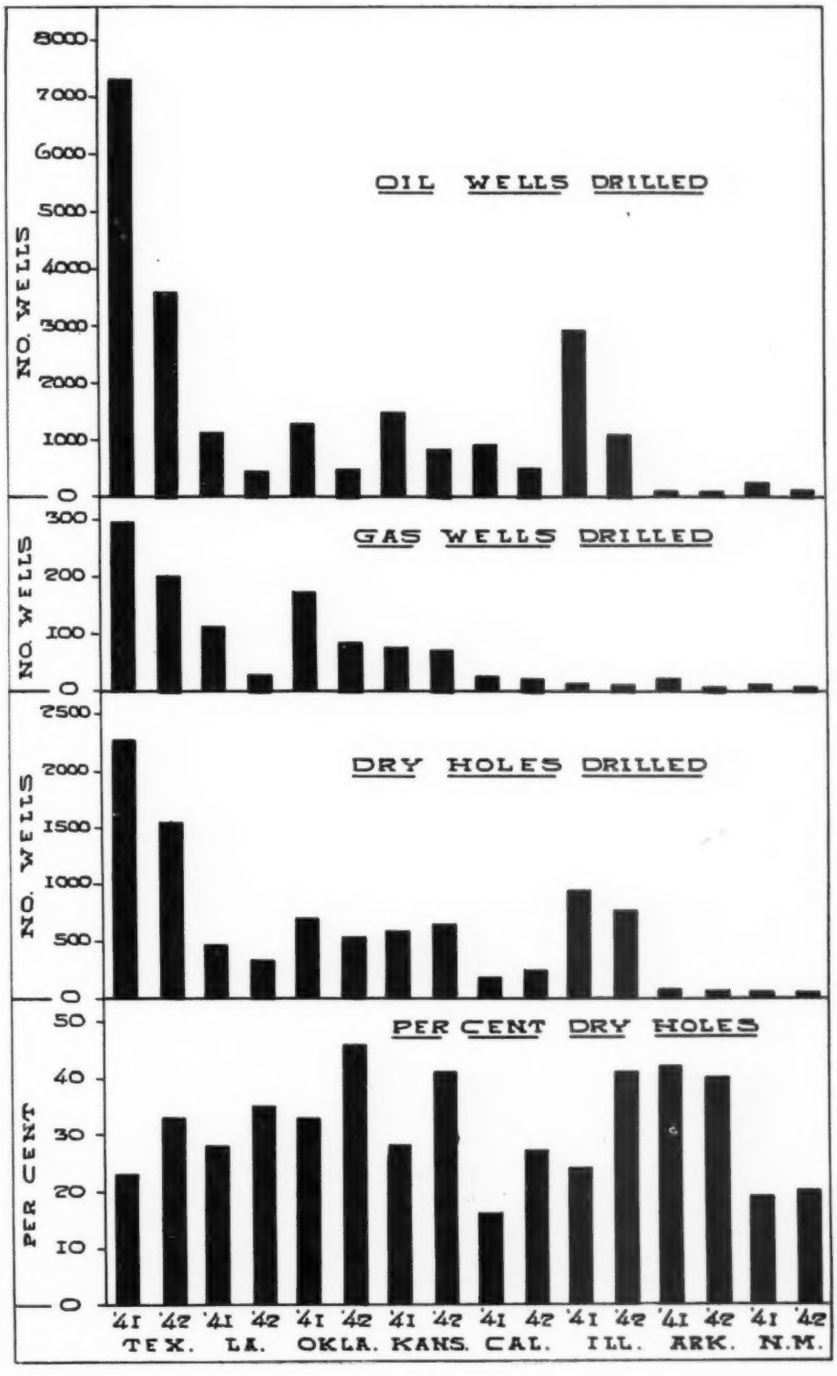


TABLE 5
Drilling statistics—1941-42

		Oil	Gas	Dry	Total	Percent dry
Texas,	1942	3,062	205	1,581	4,848	33
	1941	7,258	295	2,274	9,827	23
Percent change		—48	—31	—30	—51	+10
Louisiana,	1942	558	33	323	914	35
	1941	1,083	111	470	1,664	28
Percent change		—48	—70	—31	—45	+ 7
Oklahoma,	1942	525	84	526	1,135	46
	1941	1,235	178	697	2,110	33
Percentage change		—57	—53	—25	—46	+13
Kansas,	1942	830	77	638	1,545	41
	1941	1,436	79	597	2,112	28
Percent change		—42	— 3	+ 7	—27	+13
California,	1942	584	26	224	834	27
	1941	910	23	178	1,111	16
Percent change		—36	+13	+26	—25	+11
Illinois,	1942	1,125	13	784	1,922	41
	1941	2,912	13	913	3,838	24
Percent change		—61	0	—14	—50	+17
Arkansas,	1942	105	7	74	186	40
	1941	95	20	83	198	42
Percent change		10	—65	—11	— 6	— 2
New Mexico,	1942	186	11	48	245	20
	1941	209	16	52	277	19
Percent change		—11	—31	— 8	—12	+ 1
Other,	1942	3,498	1,648	1,345	6,491	21
	1941	6,867	2,279	1,857	11,003	17
Percent change		—49	—28	—28	—41	+ 4
U. S.,	1942	10,473	2,104	5,543	18,120	31
	1941	22,005	3,014	7,121	32,140	22
Percent change		—52	—30	—22	—44	+ 9
Wildcats,	1942	442	57	2,601	3,100	84
	1941	460	58	2,642	3,160	84
Percent change		— 4	— 2	— 2	— 2	0

Note: All 1942 figures are preliminary, subject to final revision.
Wildcats are included in drilling statistics above.

satisfactory and the immediate problem there calls for a substantial increase in wildcat operations in 1943. Only 125 wildcats were drilled in California last year and if the materials are made available there should be at least 250 wildcat operations there this year.

Found 1,700,000 Bbl. Per Wildcat Producer

With 442 productive wells completed out of 3100 wildcats drilled in the United States last year the industry added about 750,000,000 bbl. of new reserves to the underground inventory, including new discoveries and extensions to previously discovered fields. This means that each successful wildcat well was responsible for the discovery of about 1,700,000 bbl. of new oil supply. On this basis, if 4500 wildcat wells are drilled this year and 84 percent of them are dry holes, the net result may be 720 productive wells, which may result in the primary discovery of 1,224,000,000 bbl. of new oil supply. Even this greatly increased new supply would fall short of meeting 1943 re-

Fig. 4. Distribution of wildcat drilling in 1942

Each solid sphere represents approximately 1 percent of the nation's wildcat wells drilled in 1942. The open spheres indicate less-than 1 percent. A total of 3100 wildcat wells were completed in the U. S. last year

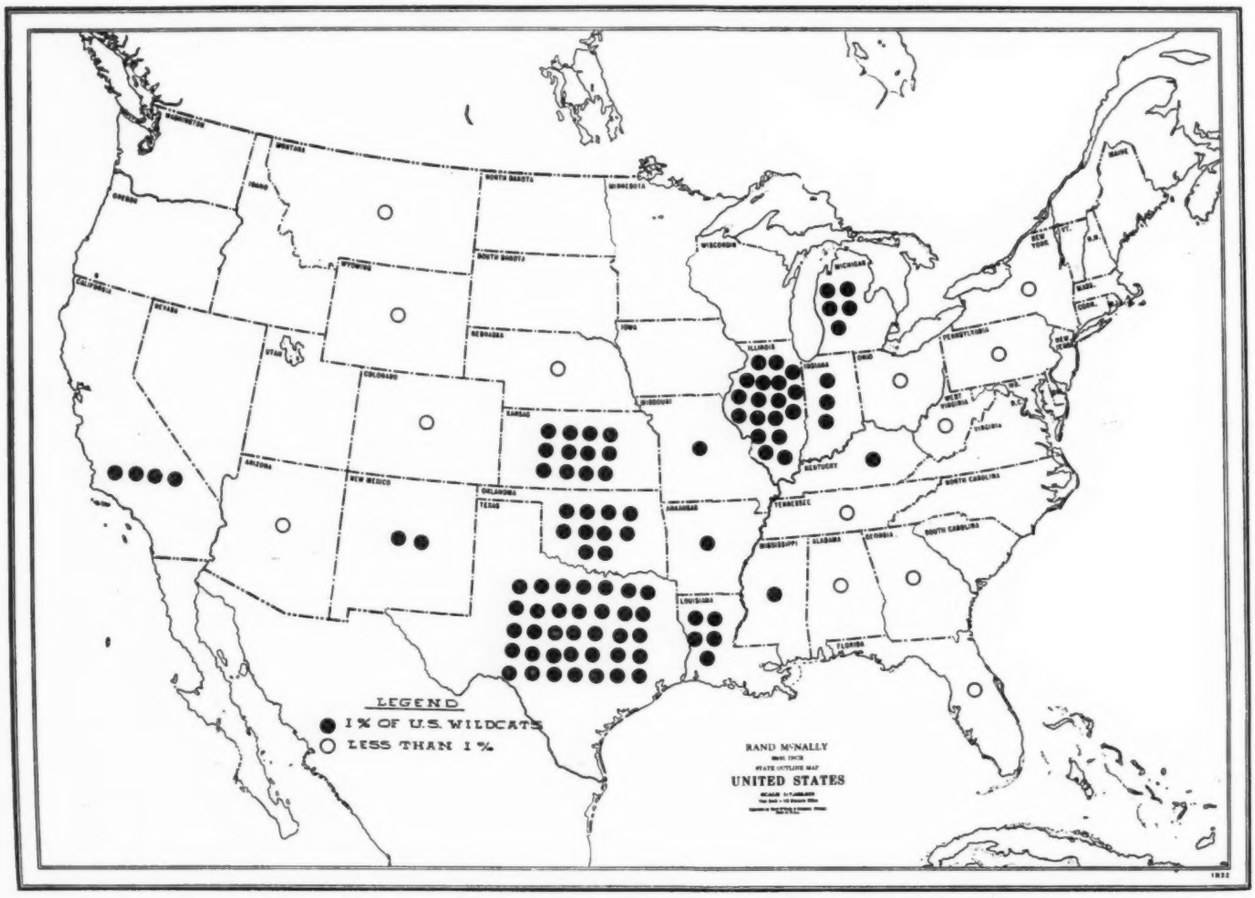


TABLE 6

Number of wells drilling

Close of 1942 and 1941

	December 31, 1942°	December 31, 1941	Change
Texas	430	1142	— 712
Louisiana	110	236	— 126
Oklahoma	220	296	— 76
Kansas	180	260	— 80
California	125	170	— 45
Illinois	210	363	— 153
Arkansas	30	28	+ 2
New Mexico	52	60	— 8
Other states	800	1443	— 643
U. S. total	2157	3998	—1841

°Preliminary—subject to final revision.

TABLE 7

United States gasoline situation

(Aviation gasoline excluded)

	1942°	1941	Change 1942 over 1941
Stocks, January 1	94,098,000	90,113,000	+ 3,985,000
Production	605,000,000	690,958,000	—85,958,000
Total	699,098,000	781,071,000	—81,973,000
Stocks, December 31	78,000,000	94,098,000	—16,098,000
Indicated demand	621,098,000	686,973,000	—65,875,000

°Preliminary—subject to final revision.
Note: Imports have been negligible. Export figures not available.

TABLE 8

United States fuel oil situation

(Light and heavy fuels combined)

	1942°	1941	Change 1942 over 1941
Stocks, January 1	133,121,000	132,244,000	+ 877,000
Production	558,279,000	531,544,000	+26,735,000
Transfers	22,712,000	15,482,000	+ 7,230,000
Total	714,112,000	679,270,000	+34,842,000
Stocks, December 31	114,000,000	133,121,000	—19,121,000
Indicated demand	600,112,000	546,149,000	+53,963,000

°Preliminary—subject to final revision.
Note: Imports and exports, eliminated, as figures are not available.

quirements by at least 250,000,000 bbl. An important factor in any extensive wildcat drilling program is the increased cost of drilling to necessarily greater depths, which has in recent years contributed to a constantly greater cost of finding new reserves.

Table 6 and Fig. 5 show drastic downward revisions in new drilling operations at the close of 1942 compared with the same period of 1941. New operations in Texas for 1942 took a sharp drop to 430, against 1142 in 1941. Practically all states, with the one exception of Arkansas, showed reductions in new drilling operations. New drilling operations in the United States on December 31, 1942, declined to 2157, against 3998 in the preceding year, a decline of 1841, or 46 percent. Nearly 40 percent of the total decrease in new drilling operations was accounted for by Texas.

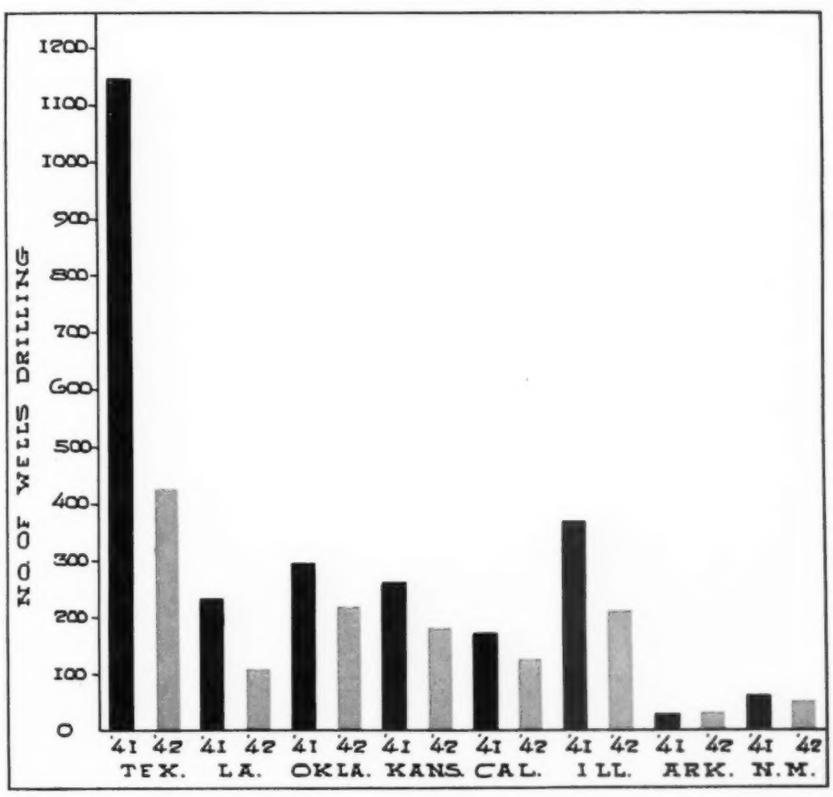
Fuel Oil Offset Gasoline Slump

Tables 7 and 8 show in detail the supply and demand pictures for gasoline and fuel oil. It will be noted that although the demand for gasoline decreased 65,875,000 bbl., the decline was offset to some extent by an increase of 53,963,000 bbl. in demand for fuel oil. In view of the critical situation in the fuel oil markets of the northeastern states, it is likely that the production of gasoline in the first quarter of 1943 will be further curtailed in order to make available a greater supply of light and heavy fuel oils. This is expected to result in a correspondingly greater demand for crude oil. If gasoline yields from crude are reduced to 35 percent in January, for example, refinery crude requirements would be increased by about 6,000,000 bbl.

The year 1938 proved to be the most recent peak year in the finding of new reserves. This is shown by crediting extensions and revisions of previously discovered oil fields to the year of their original discovery. In 1938, new reserve discoveries aggregated 1,650,000,-

Fig. 5. Status of new drilling operations of leading oil states—1941 and 1942

Black columns represent number of wells drilling on December 31, 1941. Yellow columns, number drilling same period of 1942. Details are shown in Table 6



000 bbl., bringing the underground inventory of known reserves on January 1, 1939, to 21,813,000,000 bbl. Since 1938 average annual new reserve discoveries have amounted to about 500,000,000 bbl. and the Nation's underground inventory on January 1, 1943, has decreased to 18,586,000,000 bbl.

Table 9 presents the results of a careful study of the nation's petroleum reserves, covering the period 1935 through 1942. It will be noted that new reserve discoveries between 1935 and 1938, inclusive, aggregated 7,325,000,000 bbl., whereas crude oil production during this period aggregated 4,589,000,000 bbl. During this period a surplus reserve of underground oil of 2,736,000,000 bbl. was accumulated. During the period the average ratio of discoveries to production was 1.6 to 1.

TABLE 9

Petroleum reserves and new discoveries—1935-1943

Year	Estimated reserves January 1 (million bbl.) *	New reserves discovered (million bbl.) †	Production (million bbl.)	Ratio of discoveries to production	Dry holes drilled	New discoveries per dry hole (thousand bbl.)	Dry holes per million bbl. of new discoveries
1935	19,077	2,100	997	2.106	4,911	427	2.3
1936	20,180	1,700	1,100	1.545	5,296	321	3.1
1937	20,780	1,875	1,279	1.466	6,420	292	3.4
1938	21,376	1,650	1,213	1.360	6,043	273	3.6
1939	21,813	700	1,265	.553	6,355	110	9.1
1940	21,248	590	1,353	.436	6,533	90	11.1
1941	20,485	615	1,404	.438	7,121	72	11.6
1942°	19,696	‡275	1,385	.200	5,543	49	20.2
1943°	18,586	?	§1,475	?	?	?	?

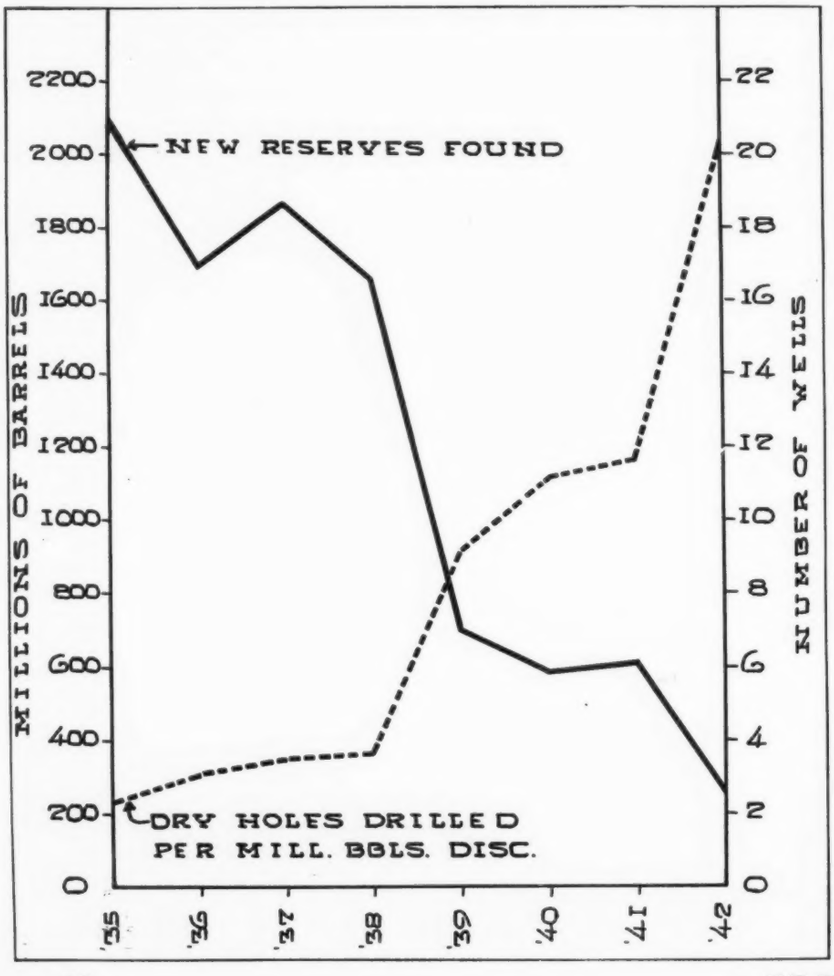
	1935-38	1939-43
New reserves discovered	7,325,000,000	2,180,000,000
Crude oil produced	4,589,000,000	5,407,000,000
Surplus	2,736,000,000	
Shortage		3,227,000,000
Ratio of discoveries to production	1.600	.403

*Revised to include subsequent extensions to original discoveries.
†Extensions and revisions credited to years of original discovery.
‡Discoveries and extensions were about 750,000,000 bbl. Figure shown represents distinctly new discoveries, which are subject to subsequent revisions and extensions.
°Preliminary—subject to final revision.
§Forecast for 1943.

Severe Shortage

By comparison, the results of 1939 through 1942 present an ominous picture. New reserve discoveries during this period aggregated 2,180,000,000 bbl., whereas crude oil production was 5,407,000,000 bbl. The final result in this instance was a shortage of 3,227,000,000 bbl., and the ratio of discoveries to production was .403 to 1.

Fig. 6. Trend of new oil reserves discovered and number of dry holes required to find a million barrels of new reserves. Details are shown in Table 9



Although preliminary estimates indicate that about 750,000,000 bbl. of new reserves were discovered in 1942, analysis shows that only about 275,000,000 bbl. of this was classed as distinctly new discoveries. The rest was credited to previously discovered producing areas. The seriousness of the nation's oil reserve situation is emphasized by the steady decline since 1935 in the ratio of discoveries to production. It is further emphasized by a study of the quantity of oil found per dry hole drilled. It will be noted in the table that 2.1 times as much reserve was found as we produced in 1935, but in 1942 exploratory effort resulted in the discovery of only one-fifth as much reserve as production. It is likely, however, that first estimates of new discoveries in 1942 and perhaps in 1941 and 1940 will be revised upward by subsequent extensions and revisions; but the fact remains that less and less new oil is found each year and extensions to previously discovered oil pools are not so large as they were in former years.

Takes 10 Times as Many Dry Holes

Fig. 6 shows what has happened in the way of new reserve discoveries since 1935 and shows the number of dry holes drilled per million barrels of new oil discoveries. In 1935, when 2,100,000,000 bbl. of new reserves were found, 4911 dry holes were drilled, which meant that it took 2.3 dry holes to find a million barrels of new oil supply. The industry in 1942, found only 275,000,000 bbl. of new reserves (first estimates) and drilled 5543 dry holes. To-

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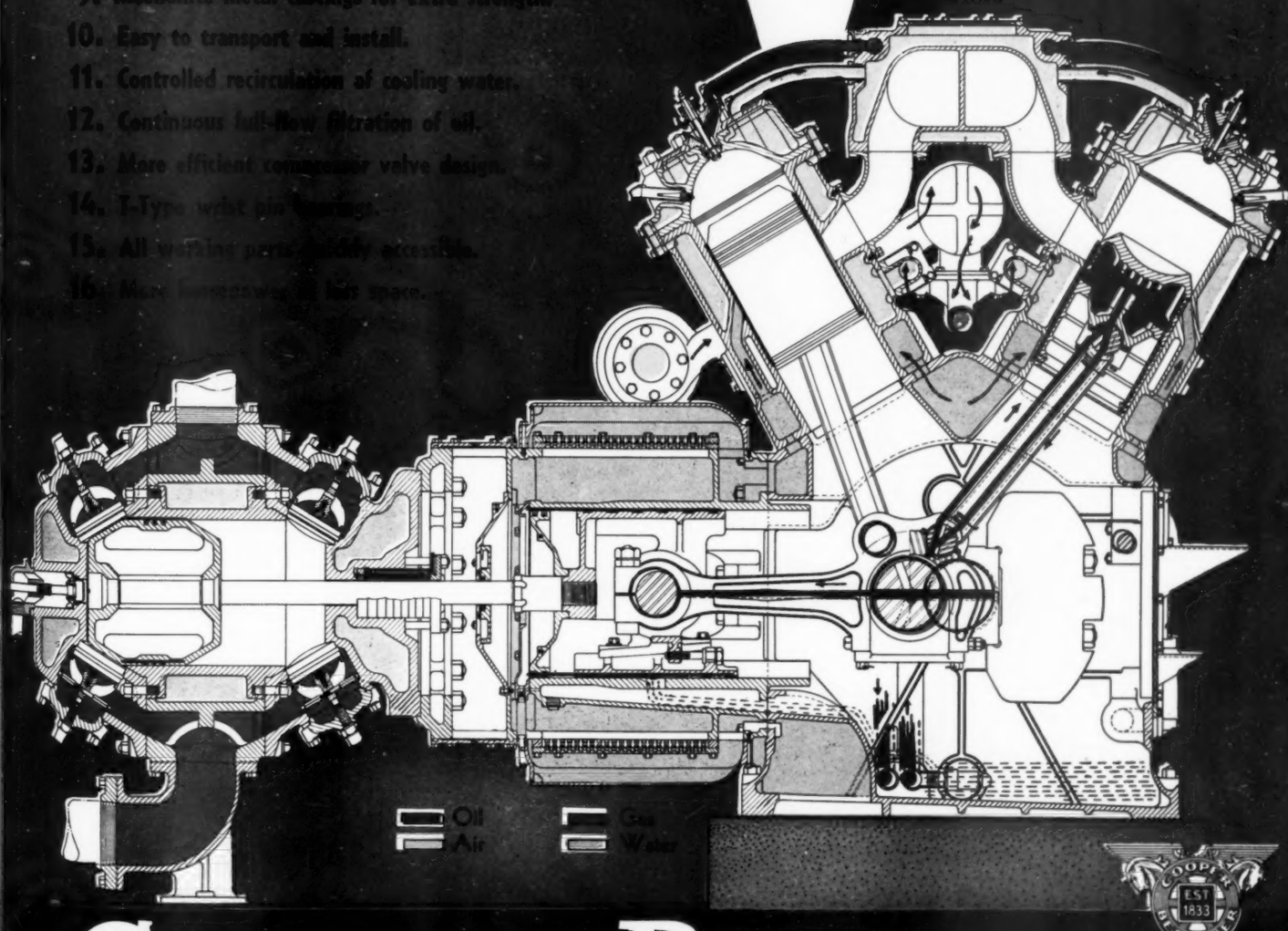

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TABLE 10
Relationship of oil reserves to production

Year	Original reserve estimate (January 1)	Adjusted reserve to include extensions and revisions (January 1)	Annual production	Ratio of reserves to production (Col. 2÷3)
1935	12,177,000,000	19,077,000,000	997,000,000	19.1
1936	12,400,000,000	20,180,000,000	1,100,000,000	18.3
1937	13,063,000,000	20,780,000,000	1,279,000,000	16.2
1938	15,507,000,000	21,376,000,000	1,213,000,000	17.6
1939	17,348,000,000	21,813,000,000	1,265,000,000	17.2
1940	18,483,000,000	21,248,000,000	1,353,000,000	15.7
1941	19,025,000,000	20,485,000,000	1,404,000,000	14.6
1942	19,221,000,000	19,696,000,000*	1,385,000,000	14.2†
1943	18,586,000,000°	18,586,000,000*	1,475,000,000‡	12.6†

*Subsequent extensions and revisions to be added.
°Preliminary—subject to final revision.
†Upward revision anticipated.
‡Estimated for 1943.

day it takes 20.2 dry holes to find a million barrels of new oil supply!

On the basis of adjusted reserves, to include extensions and revisions, the total reserve supply of crude oil as measured by annual requirements has been shrinking since 1935. In 1935 the ratio of reserves to production was 19.1, whereas on January 1, 1943, in the light of this year's probable demand for crude oil, the ratio is only 12.6 (Table 10). This does not mean that there is 12.6 years' supply of oil underground, which could be produced at current rates during that period. As a matter of fact, known reserves will probably not be exhausted for at least 26 to 30 years, but unless additional sources of supply are found our annual rate of production cannot long be maintained at present levels.

Reserve Adjustments

Fig. 7 shows what has happened since 1935 in the way of adjustments to original reserve estimates. In 1935, it was originally estimated that the underground reserve supply amounted to 12,177,000,000 bbl. Subsequent extensions and revisions added nearly 7,000,000,000 to this figure, resulting in an upward revision of known reserves to 19,077,000,000 bbl.

In 1939, the original reserve estimate was 17,348,000,000 bbl., which was subsequently revised to 21,813,000,000 bbl. Thus, within a period of only four years the additions by extensions and revisions dropped from 7,000,000,000 to a little more than 4,000,000,000 bbl. By 1941 the revision amounted to only a little more than 1,000,000,000 bbl. and in 1942, subject to further upward revision, the increment was but 475,000,000 bbl. to be credited to previous discoveries.

The peak of the nation's proved underground oil reserves was reached in 1939. Since then the inventory of oil underground has shown a far too rapid decline. The chart shows the relationship between total reserves, the lessening rate of upward revisions by extensions, and the sharp downward trend in the ratio of reserves to annual crude oil production.

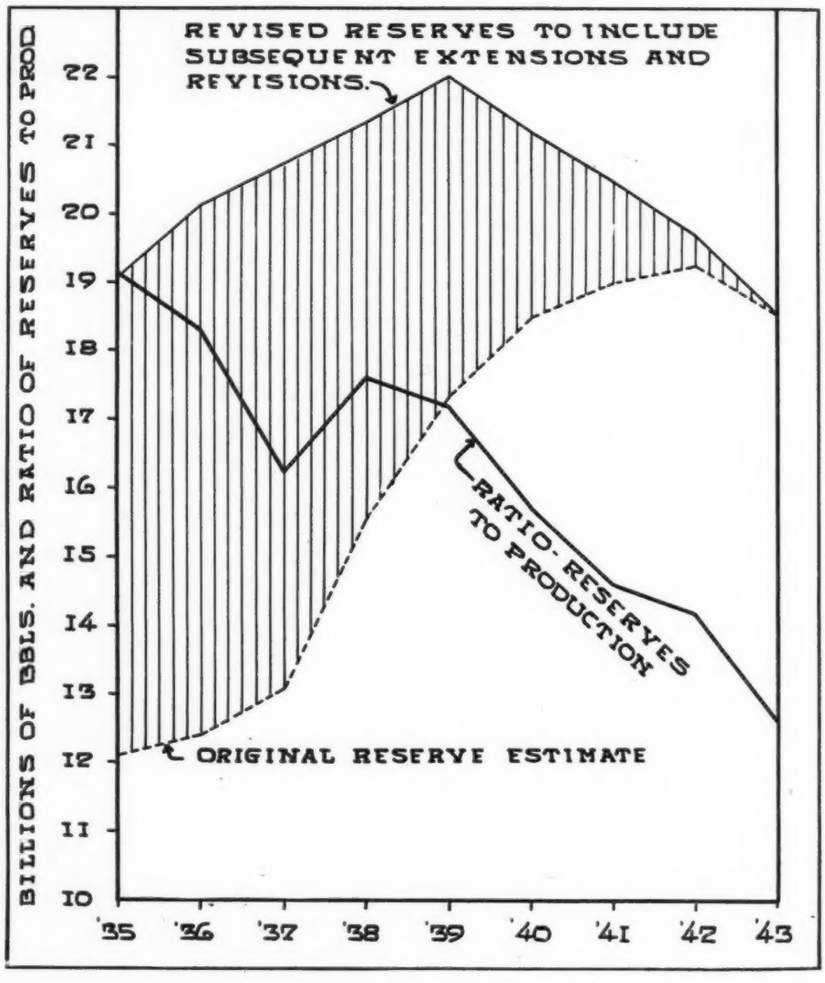
Exploration Cost Important Factor

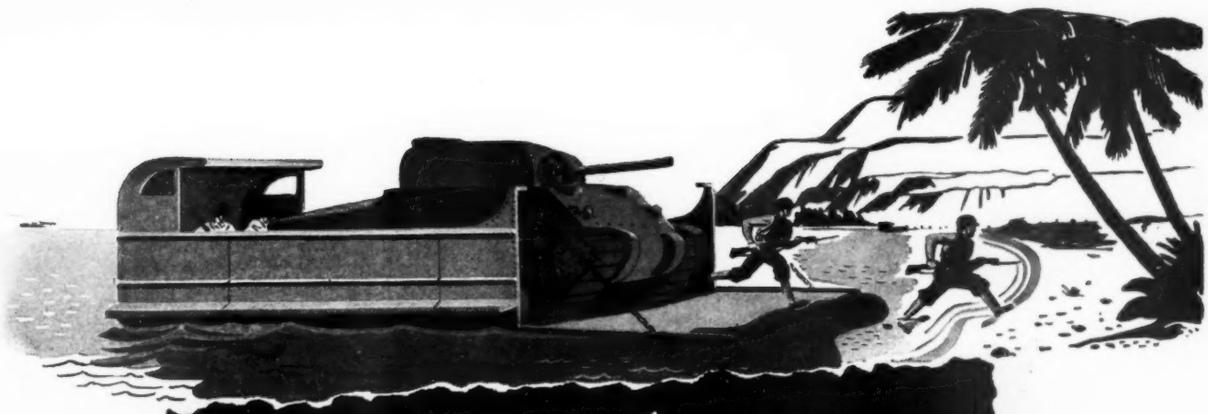
A factor of far-reaching importance to the discovery of new oil reserves is the cost of exploration. To give some idea of this situation, the writer has made a careful study of known factors in connection with the cost of acquiring and carrying leases, geophysical and geological exploration, and the cost of drilling exploratory wells. This study makes it evident that the cost of finding new oil reserves has shown a sharp increase since 1935.

Finding Cost Increasing

Table 11 presents the results of this study of the cost of finding oil in the United States. In arriving at the cost of new oil found, it is necessary to consider all discoveries, including new fields and extensions to fields previously discovered. Against this new oil supply must be charged the cost of drilling all wildcat producing oil wells completed and all wildcat dry holes, as well as the cost of drilling all other dry holes during the year. To this must be added a

Fig. 7. Trend of petroleum reserves, effect of extensions and revisions resulting from original new oil discoveries, and course of reserves in relationship with production requirement. Details are shown in Table 10





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proportionate cost of acquiring and carrying leases, geological and geophysical exploration cost, and a proportionate share of the overhead and administrative cost. With these costs computed it is possible to determine the approximate cost per exploratory well and the cost per barrel of new oil found.

In 1935, new reserve discoveries were estimated at 1,220,000,000 bbl., including extensions. During that year the industry drilled 5231 dry holes and discovery wells at a total cost of $57,639,000. In addition, the industry spent $104,620,000 in lease and exploration costs, including overhead, which made the total expenditure for that year about $162,259,000. As a result, the average cost per exploratory well was about $31,000 and the cost per barrel of new oil found about 13.3 cents. It took 4.3 exploratory wells to discover a million barrels of new oil supply.

In 1937, the industry found more than three times as much oil as was discovered in 1935, or a total of 3,723,000,000 bbl. As a result, the cost of finding oil that year, despite the fact that the cost per exploratory well was increased to $34,000, averaged only 6.3 cents per bbl.

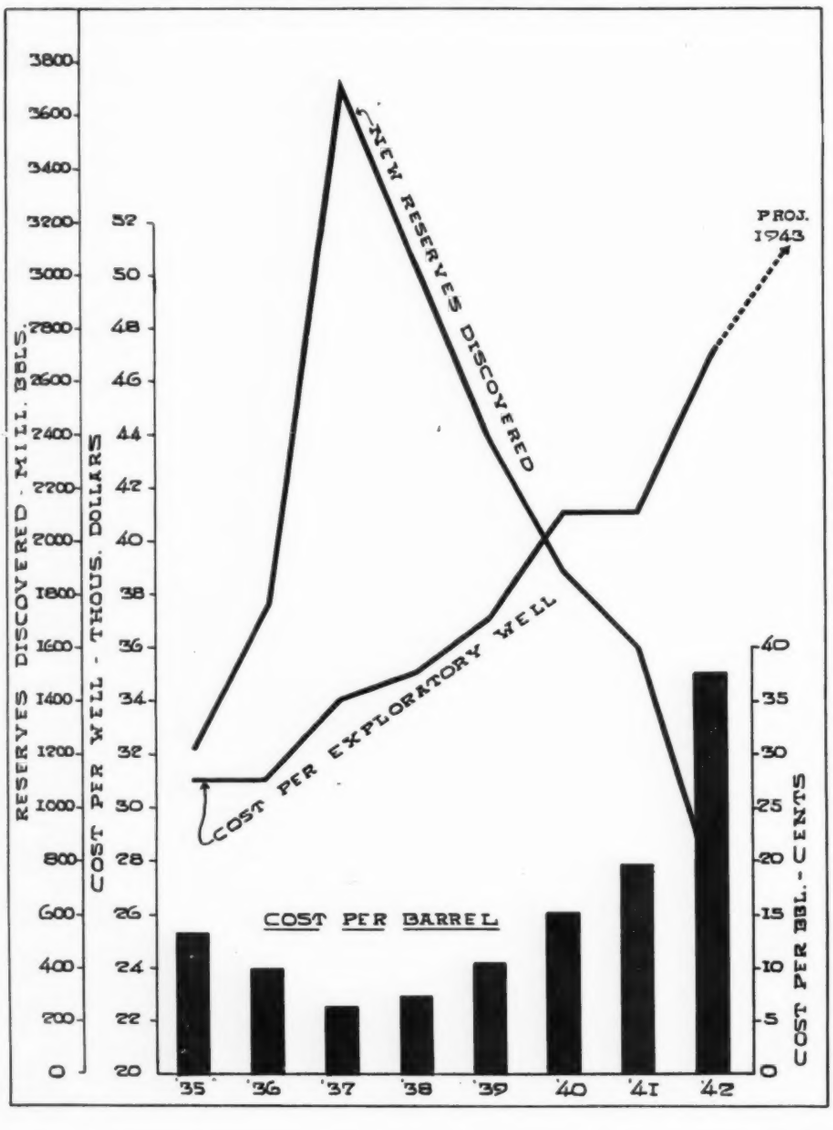
TABLE 11

Cost of finding oil in the United States—1935-1942

Year	Reserves discovered (million) †	Dry holes and discovery wells drilled	Drilling cost, thousand $	Lease and exploration cost, thousand $ ‡	Approximate total cost, thousand $	Cost per exploratory well	Approximate cost per barrel, cents §	Exploratory wells drilled per million bbl. of reserves found
1935	1,220	5,231	57,639	104,620	162,259	31,000	13.3	4.3
1936	1,763	5,671	63,414	113,420	176,834	31,000	10.0	3.2
1937	3,723	6,900	85,320	151,800	237,120	34,000	6.3	1.8
1938	3,054	6,453	81,750	141,966	223,716	35,000	7.3	2.1
1939	2,400	6,732	90,177	161,568	251,745	37,000	10.5	2.9
1940	1,895	7,032	102,644	182,832	285,476	41,000	15.1	3.7
1941	1,600	7,581	116,083	197,106	313,189	41,000	19.6	4.7
1942°	750	5,985	114,916	167,580	282,496	47,000	37.6	8.0

†Includes new discoveries, and extensions to previously discovered fields.
‡Includes prorata cost of acquiring and carrying leases, geological and geophysical expense and proportion of overhead chargeable to exploration and development.
§Based upon original reserve estimates at time of discovery. Subsequent extensions and revisions are considered in relationship to costs subsequently incurred.
°Preliminary—subject to final revision.

Fig. 8. Course of new reserve discoveries and cost of exploration since 1935
Columns show trend of oil finding cost. Details are shown in Table 11



1942 Cost Three Times Greater

In 1942, the industry found only 750,000,000 bbl. of new reserves and the cost per exploratory well had increased to $47,000, making the average cost per barrel 37.6 cents. In 1937, it took only 1.8 exploratory wells to find a million barrels of new oil supply, whereas in 1942 it took the drilling of eight exploratory wells to find a million barrels of new reserve.

Fig. 8 presents a graphic view of the course of new reserve discoveries, the trend in cost of drilling exploratory wells, and the estimated average cost of finding oil since 1935. The data upon which this study is based are believed to provide a reliable index of the cost of exploration for oil in the United States. The results of this study are presented to the industry at this time in order that there may be a more widespread realization of the conditions under which the petroleum industry must carry on its operations and pursue its continual search for new sources of oil supply.

A projection of the cost of exploratory drilling through 1943, based upon the outlook as it appears today, indicates that the average cost per exploratory well this year will exceed $50,000.

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PETROLEUM ENGINEER Exclusive Feature

by
Frank H. Love
Managing Editor

Strategic Pipe Line Constructed Using Minimum of New Materials

☆ Novel methods employed in laying line through swamps

CONSTRUCTION is nearing completion on the 260-mile Bayou Pipe Line System from Baytown, Texas, to Baton Rouge, Louisiana, designed for the dual purpose of increasing supplies to the Plantation Pipe Line and releasing barges that have been making deliveries to that system at Baton Rouge.

The Bayou system consists of 8-in. pipe from Baytown to Port Neches, Texas, and of 10-in. from the latter point to Baton Rouge, a total of 260 miles. In addition, feeder lines to the Baytown station have been laid that include 3 miles of 8-in. from the Humble refinery at Baytown, 30 miles of 6-in. from the Pan American refinery at Texas City to Baytown, 10 miles of 6-in. from the Shell Refinery at Deer Park, and 5 miles of 4-in. from the Crown Central refinery at Pasadena to connect with the line from Deer Park.

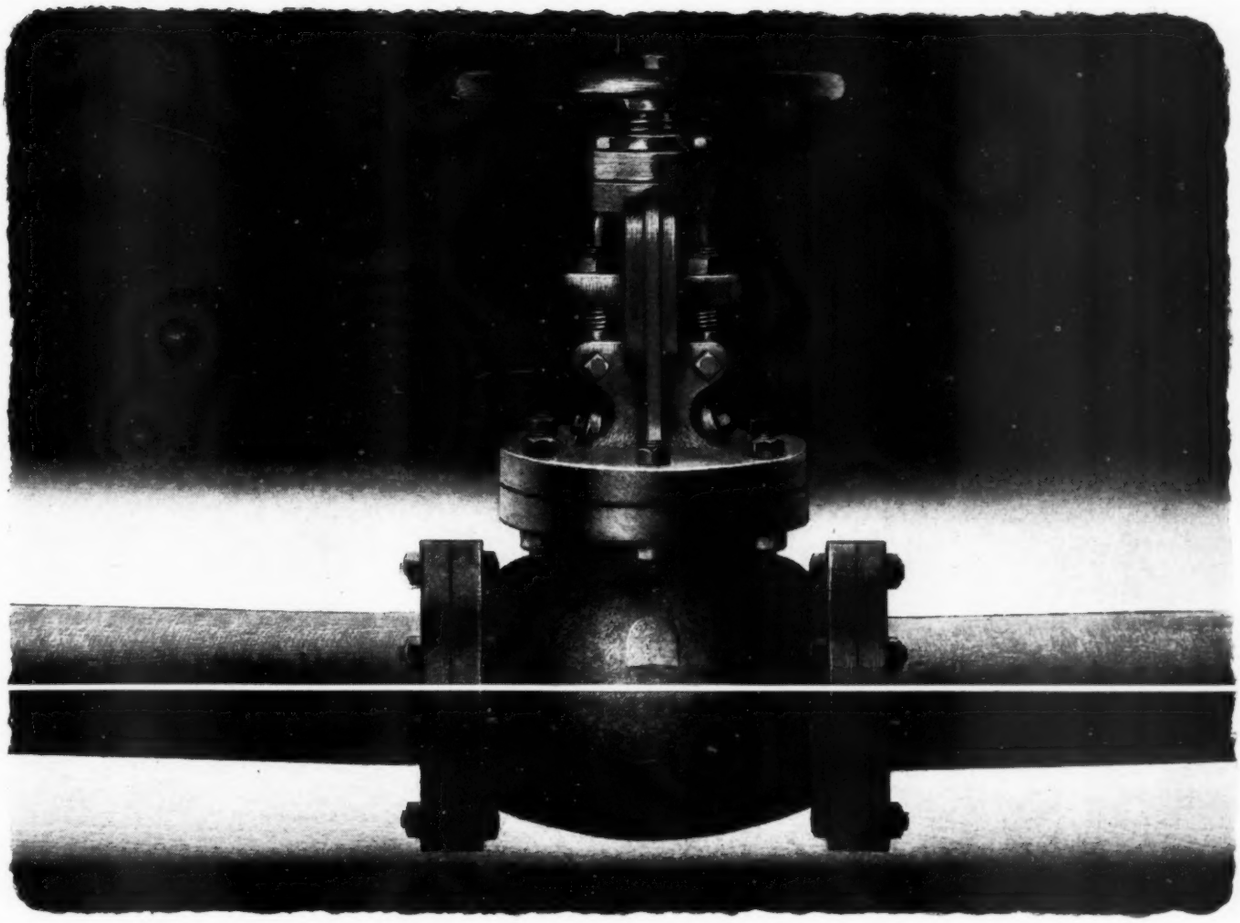
Feeding into the Neches station, The Texas Pipe Line Company and the Pure Transportation Company, respectively, have laid 9 miles of line from the Texas refinery at Port Arthur and 5 miles of 6-in. line from the Pure refinery at Smith's Bluff.

Participants in the project, which was designed, constructed, and will be operated by Shell Pipe Line Corporation, are Humble Pipe Line Company, The Texas Pipe Line Company, Pure Transportation Company, Pan American Pipe Line Company, and Crown Central Pipe Line and Transportation Corporation.

Eleven pumping stations are being erected. Those at Baytown and Neches will be terminals.

In keeping with the oil industry's policy of shouldering its share of the war burden while at the same time utilizing a minimum of new material, most of the material used on this project was secondhand equipment contributed by the participating companies. Pumping units and tanks were entirely reclaimed by these companies or purchased secondhand from others. Line pipe was taken up from ten sections throughout the Mid-Continent and Gulf Coast areas, reconditioned, and shipped to strategic points on the line. A relatively small amount of new pipe was purchased for use at river crossings. How almost completely this line is "secondhand" is attested by the fact that of its total cost of $7,000,000, only $1,000,000 was spent on new materials for which preference ratings were required.

Hot coal-tar enamel being applied over the line by a traveling-type machine



GUARD YOUR VALVES GIVE THEM PROPER SUPPORT!

PROVIDE EXPANSION BENDS OR JOINTS

Don't so install valves that they carry the weight, sag or expansion of the line. Valves are not designed to carry that type of load. Distortion will result in inefficient operation, jamming, and need for early maintenance. Maintenance materials, you must remember, also are on the critical list.

It might be a good idea to approach inspection of every valve with one thought, *"What's wrong with this?"* Guard your valves. They will last longer.

Don't Use Gate Valves or Cocks for Throttling . . .

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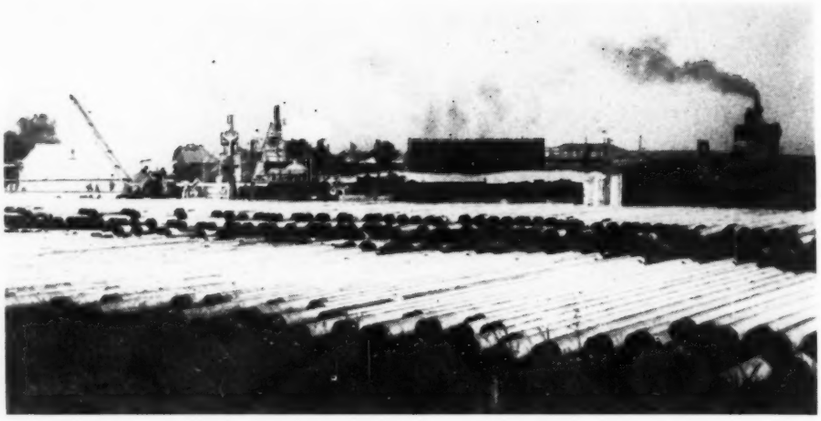
Construction Features

Most of the line was laid through some of the "toughest" pipe-line country to be found anywhere. Swamps, bayous, rivers, and rice fields presented formidable difficulties. Such natural hazards were virtually continuous from Cedar Bayou in Texas to the Calcasieu River in Louisiana.

To anyone who has not assisted in or at least viewed this work, the problems of laying a pipe line through the swampy area of Texas and Louisiana are hard to visualize. Numerous "corduroy" roads were built to make the right-of-way accessible to equipment, generous use was made of tractors to assist trucks in places where such roads were unavailable and, in several areas into which conventional laying equipment could not penetrate under any circumstances, the pipe had to be "pushed" into place.

The most difficult part of the line construction was "the big push" through the wild Neches River swamp. The first step in this operation, as in similar ones, was to cut a trench by means of two swamp buggies pulling a plow. Then to the first joint of pipe was welded a section of 16-in. pipe to give it buoyancy. Lengths of pipe were welded on, joint by joint, and pushed into the inaccessible swamp. This last procedure was accomplished by employing two tractors to which were attached cables. By means of blocks and tackles each tractor could handle several cables, which were looped around the pipe at intervals of 250 to 300 ft. The tractors actually pulled the pipe strings insofar as their limited working area was concerned, but had the effect of pushing the strings through the swamp. To prevent the front end, to which the 16-in. length of pipe was attached, from floating out of the trench and leaving its course, a workman in a swamp buggy moved along with it and easily guided the pipe back into the ditch when it showed a tendency to "wander". The Neches River swamp is 18,000 ft., or more than three miles in width.

All river crossings, even that of the Mississippi which was 2700 ft. wide, were made by pulling the pipe into position after the joints had been added on shore. Dual lines were laid across the Mississippi and Atchafalaya rivers, but single lines serve across several other lesser rivers and bayous. Something of a departure was made from customary practice in that no river clamps were



Somastic coating plant at Port Neches, Texas

Applying enamel and wrapper to the pipe with a holiday detector following closely behind

By viewing this photograph a partial idea may be gained of the type of country through which most of the line was laid

used. This was possible because of added weight given by the weight of the asphalt-mastic type coating.[1] All crossings were ditched 2 ft. except the Mississippi and Atchafalaya, and in all instances the pipe was given a "comber" upstream to prevent its becoming taut as it gradually embeds itself deeper into the channel.

Other than in the swampy and marshy areas, conventional methods of pipelining were employed with respect to ditching, lining-up, welding, lowering-in, and backfilling. Except for a few instances when local conditions made "roll welding" more convenient, the stove-pipe method of construction was used.

On that part of the line traversing wet terrain, such as swamps, marshes, rice fields, etc., and on all river crossings, the asphalt-mastic type of coating was used. This included all but about 65 miles of the 10-in. line on which a primer, felt wrapping, and hot coal-tar enamel[2] were applied. The latter was applied over the trench by a traveling-type combination coating and wrapping machine. Three asphaltic-mastic coating plants, at Houston and Port Neches, Texas, and Blanks, Louisiana, were established. The bare pipe was shipped into these plants, shotblasted with steel grit, primed with asphalt base primer, and the asphalt-mastic protective coating applied to a thickness of approximately ½ in.

[1] *Somastic* by Industrial Engineering Company.
[2] By The Barrett Company.

Stations and Terminals

The 8-in. section of the line, from Baytown to Port Neches, is designed for movement of 37,000 bbl. of gasoline per day. On this section, besides the initial station and tank farm at Baytown, there are stations at Hankamer and Fannette. Pumping equipment at all stations consists of 3600-r.p.m. centrifugal pumps driven by 350-hp. motors. At Baytown there are three such units, two of which normally will operate in series, with the third serving as a standby. At Hankamer and Fannette, each, two such units will operate in series, no standby being provided. Working storage at the Baytown terminal comprises eight tanks having a total capacity of 275,000 bbl. From Neches station, near Port Neches, into Baton Rouge the 10-in. section of the line is designed to move 60,000 bbl. of gasoline per day. The line probably will transport four products, namely No. 2 heating oil, kerosine, and two grades of gasoline. Kerosine and No. 2 heating oil, having higher viscosities than gasoline, will move through the line at somewhat lower rates.

Seven tanks are being erected at the Neches station having a total capacity of 285,000 bbl. At this station three 500-hp., 3600-r.p.m. motor-driven centrifugal pumping units are being installed, two to operate in series with the third used as a standby. Buhler, Basile, and Courtableau stations, the third, fifth, and seventh on this section of the line, each will have two similar units to operate in series without standbys. The even-numbered stations at Vinton, Edna, Lawtell, and Erwinville each will have two 400-hp., 1800-r.p.m. motor-driven units. Here the need to fit the job to the equipment at hand is well-illustrated. The odd-numbered stations will serve about 25 miles of line each, whereas the intermediate ones can move equal volumes through only 20 miles of line.

Delivery at Baton Rouge will be into tanks of the Plantation Pipe Line Company for further movement by that company to terminals along its lines east of Louisiana.

Public utility electric power will be used to energize the stations. Nine will be served by Gulf States Utilities Company, one by Houston Lighting and Power Company, and one by Gulf Public Service Company.

The basic plan is to meter all feeder lines into the two terminals. Tankage is provided only for accumulating shipments and to compensate for the difference between flow rates of the feeder and trunk lines.

Completed sections of the line are being given a hydrostatic water test of 900 lb. Normal operation will be with a maximum pressure of 770 lb. at the stations, thus providing an adequate safety factor.

Contractors

General contractors for laying the pipe are I. C. Little, Dallas, Texas; O. R. Smith, Odessa, Texas, and Williams Brothers, Tulsa, Oklahoma. The L. E. Myers Company of Chicago, Illinois, is supervising the station construction, and Steel Tank Construction Company, Dallas, Texas, is erecting the tankage.

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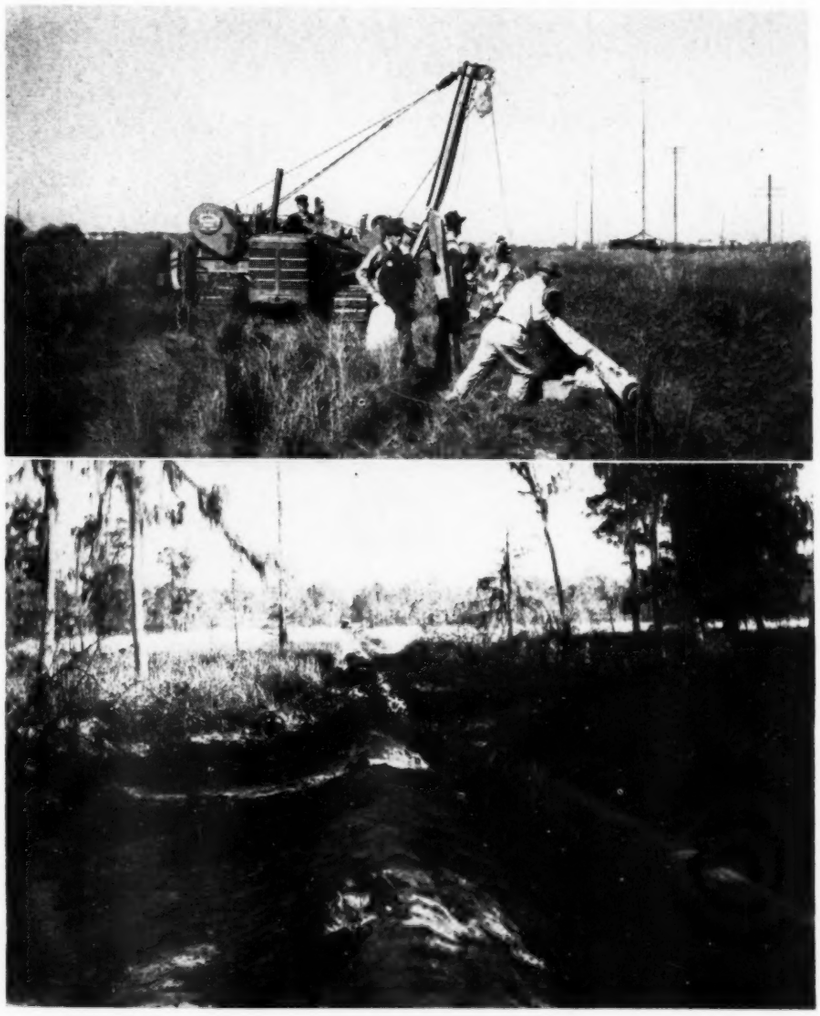


Above—"Stove-piping" a joint of pipe
Below—Through swamps of this type the pipe had to be "pushed"

REH
ANDW

This double drum rig with spudding assembly is available in three sizes for cable tool workover jobs to 10,000 feet.

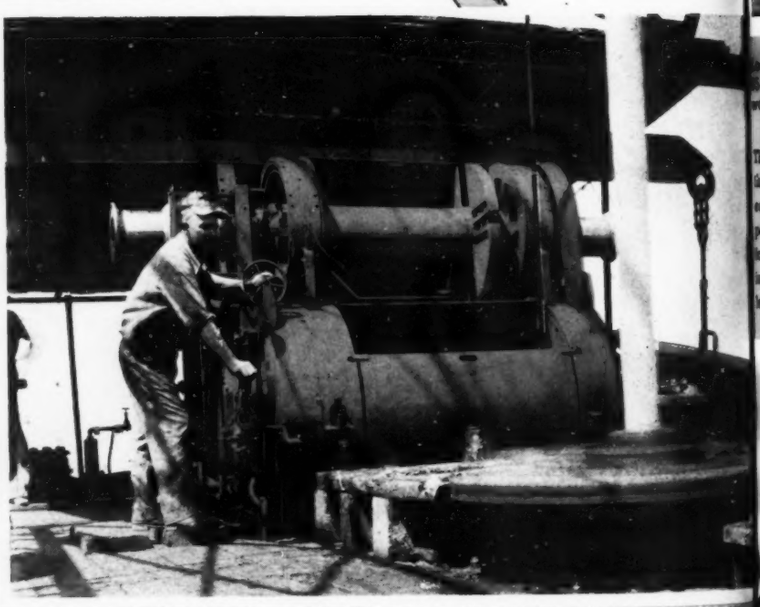
Four reasons why a "Cardwell" will make you more money:

LOW INITIAL COST — MORE FOR YOUR MONEY — The biggest value in oil field equipment comes from "Cardwell". These rigs are not manufactured by a hit-or-miss method, they are designed so you can get the most out of them at the lowest operating costs. An average of $500 is spent on each rig for the heat-treatment of all wearing parts. This exclusive "Cardwell" feature saves you thousands of dollars in down time and repair parts. We know this to be a fact, because our records show that during an equal length of service, we supplied our early type rigs with twice the repair parts we do our present models performing the same operations. You get more for your money with "Cardwell" equipment.

OPERATES FASTER — You can count on saving time with a "Cardwell" from the moment you move it on location. There's no extra spotting or handling because the rig is compact and complete. When operating, the friction clutch driven drums save time and give easy control of the drill pipe or cable tools. The dual safety braking system operates with one-half the brake lever pressure ordinarily required.

DOES MORE JOBS — The rotary table drive assembly is interchangeable with the spudding assembly. This makes a combination rig that can be changed over in the field in three to four hours for either cable tool or rotary drilling and workover jobs. Each assembly makes this combination rig just as efficient as a single purpose rig and greatly increases its value. These rigs make a real investment for either the large operator or small contractor because they fit the job and keep going with a minimum of down time.

SERVICE WHEN YOU NEED IT — You can still count on "Cardwell" to give you the best oil field service. A 24-hour parts service, 365 days in the year, is maintained at the plant and at each of the ten strategically located parts stock stores in the United States. The ordering of replacement parts is simple because completely illustrated parts books covering every "Cardwell" machine are filed at the plant and a duplicate sent to the parts stock store in the territory in which the machine is delivered.



Only $580 for rotary table drive assembly changes this rig from a cable tool rig to a draw works.

Three sizes of double drum combination drilling rigs are available for cable tool workover jobs to 10,000 feet and rotary workover jobs with tubing or light drill pipe to 10,000 feet. The same rigs can be used for cable tool drilling to 7,500 feet and rotary drilling with 4½-inch drill pipe to 5,000 feet.

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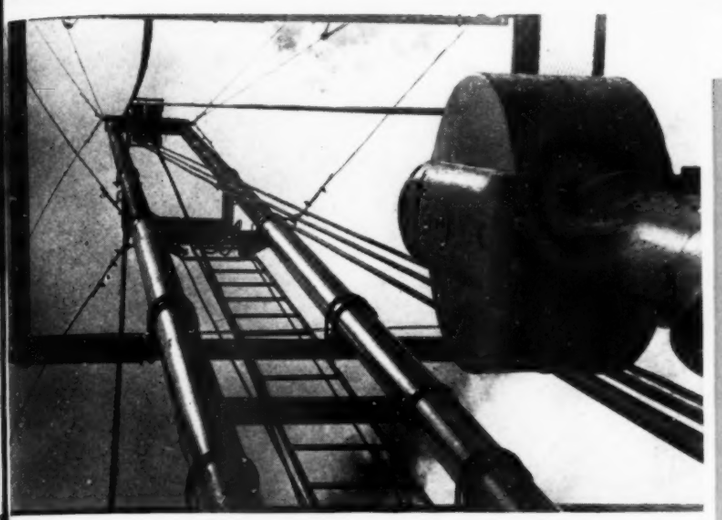

...oking up from the drilling floor. Notice the absence of obstructions. This same ...- or 87-foot double leg drilling mast can be used for either rotary or cable tool ...workover jobs.

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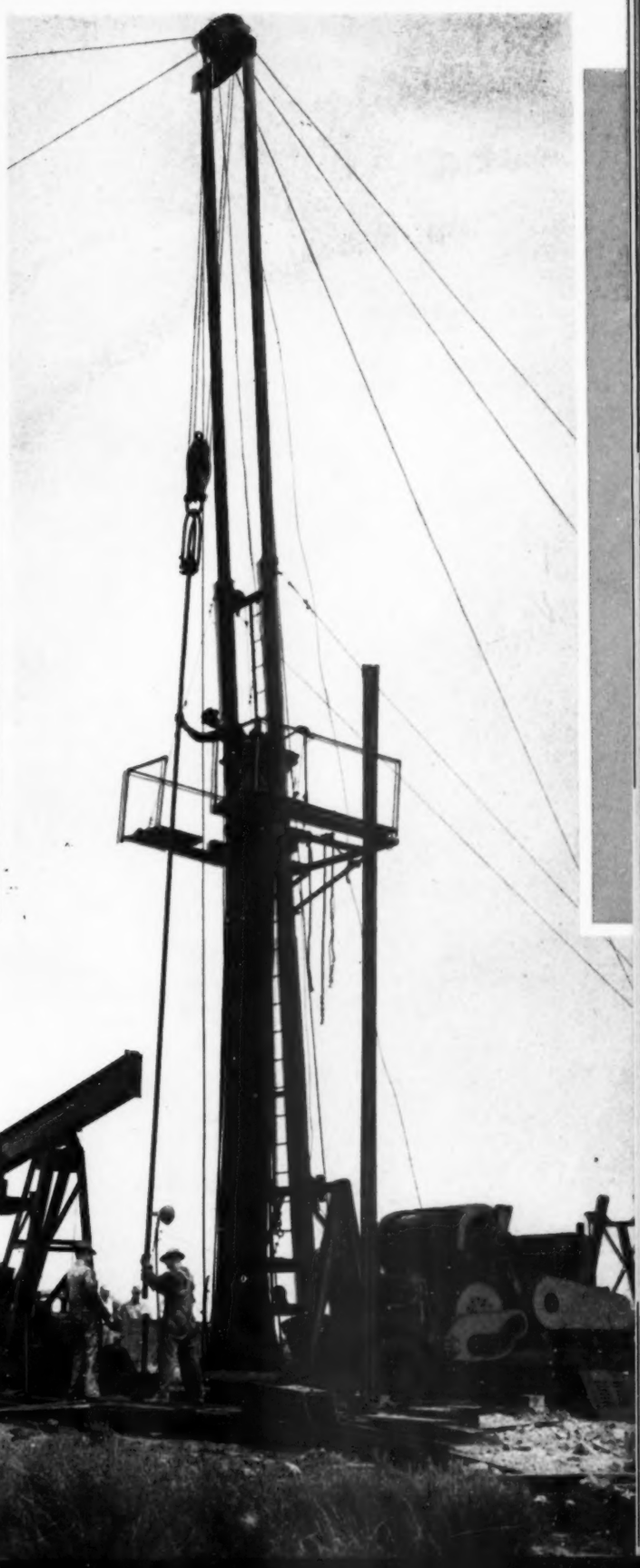

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P 420.11
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Radioactivity and Geochemical Well Logging

☆ The fundamental principles involved, equipment and methods of procedure, and possible future utility of these well-logging systems

by Lester C. Uren

Professor of Petroleum Engineering, University of California

LESTER C. UREN

IN THE December, 1942, issue of *The Petroleum Engineer*, appeared the first of a group of articles reviewing progress in the development of new methods of logging oil and gas wells. This initial article was devoted to a discussion of the principles of electrical logging and interpretation of records procured by this method. In this, the second of the series, the radioactivity well logging and geochemical well logging methods are explained. Later articles of the series will be concerned with caliper logging, temperature logging, rate-of-penetration logging, and logging by inspection of the drilling fluid.

Radioactivity Well Logging

Within recent years, there has been developed a unique system of logging that involves measurement of radioactive emanations from the strata exposed in the walls of the well. It has been shown that this property of rocks is sufficiently characteristic to afford a means of distinguishing between shales and sands, limestones, salt, anhydrite and other materials frequently present in sedimentary formations. A continuous record of radioactivity, obtained by traversing the well with an instrument sensitive to these emissions, is automatically correlated on a chart with a scale proportional to the depth of the well. Variations in the lateral amplitude of the radioactivity profile develop a pattern that is characteristic of the formations traversed. These patterns apparent in the radioactivity logs of different wells in the same locality, are often sufficiently similar to permit of accurate stratigraphic correlations. Radioactivity emissions are capable of passing through steel and cement and are uninfluenced by fluids present in the well or by temperature and pressure conditions. Radioactivity logging is therefore particularly useful in logging formations sealed off behind casing in previously drilled wells for which no electrical logs are available.

This method of logging was developed by two American service organizations, Wells Surveys, Inc., and Engineering Laboratories, Inc. Patents controlling use of the method have been granted to Well Surveys, Inc. Lane-Wells Company, a service organization, has been licensed to use the method in the United States, and the Seismograph Service Corporation controls its use in South American countries. First commercial use of the method was as recent as May, 1940. Though many wells have now been logged by this means and its dependability fully established, the method is still under development and its ultimate possibilities are perhaps not as yet fully visualized.

Theoretical basis for radioactivity logging. Certain substances appear to be of unstable constitution, disintegrating spontaneously to form other substances of lower molecular weight, of different physical and chemical properties. In this transformation, energy is liberated in a form that is characterized by electronic discharges to which the term "radioactivity" is applied. Particles of matter expelled at high velocity from radioactive substances, give rise to several fundamentally different types of emanations, among which are so-called "beta rays" and "gamma rays." Beta rays are a manifestation of electrons in process of being expelled at high velocity from the parent material. When they strike other substances, they produce electromagnetic rays, which are the "gamma rays." Gamma rays are like light rays but are of much shorter wave length. They display the penetrating effects of X-rays, characteristic of radium emanations, and are capable of being detected with sensitive instruments through several inches of steel casing or cement on the wall of a well.

Many naturally occurring mineral substances exhibit radioactivity in varying degree. Radium, a highly radioactive substance, is widely distributed in primary rocks, but in very minute amounts. Uranium, actinium and thorium are also radioactive elements that disintegrate to form other radioactive substances widely distributed in nature, the stable end product of which is the non-radioactive element lead. Measurable quantities of the disintegration products of these radioactive elements are found in rocks of all ages and all kinds—igneous, metamorphic, and sedimentary. They are found in water, both fresh and salt, in mineral oils, and even in the atmosphere.

The early disintegration of a primary radioactive element is rapid, but the products of disintegration apparently do not reach energy equilibrium, even in geologic time. As granite and other acidic primary igneous rocks high in radioactivity are transformed into metamorphic and sedimentary formations, the radioactive elements persist and by some process of nature not fully understood, are apparently concentrated in some types of strata in preference to others. Perhaps adsorption phenomena and compaction of sediments under water may be responsible for the fact that shales ordinarily exhibit greater radioactivity than sands and sandstones. Some authorities suggest that certain micro-organisms are responsible. Pure quartz sandstones and limestones

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IN POINT OF RESPECT, the President's flag is second only to the flag of the United States. Emblazoned in its center is the President's Seal, which is the same as affixed to treaties, commissions and other important documents bearing his signature.

The flag is raised when the President boards ship and remains aloft until his departure. Its raising and lowering is ordinarily accompanied by a 21-gun salute. It is also flown above the White House or other place established as personal headquarters of the President during his visit.

Each of the nine Cabinet positions has its individual flag and color. Both are of the same design, varying only in size, and each has its specific occasion of proper usage.

Flags of assistants to the Secretaries and Generals in the Cabinet are the same as their superior's, except that the colors of the field and embellishments are reversed; however, the device in the center of the flag remains in proper heraldic tinctures on all except flags of the Secretaries of the Navy, Treasury and Commerce.

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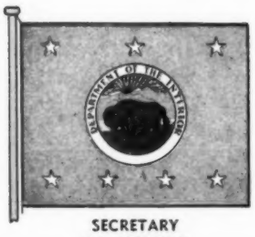

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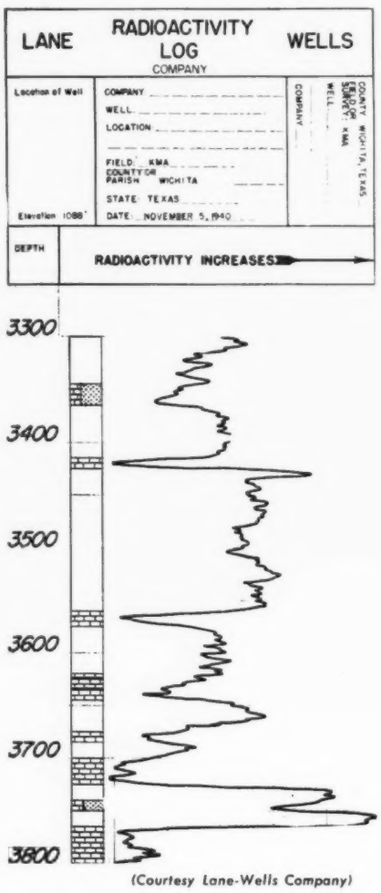
display very low radioactivity. Coal is also weakly radioactive, as are salt, anhydrite and other salines. Shales and clays, particularly certain dark-colored marine organic shales, rich in potassium compounds, customarily exhibit a high degree of radioactivity. In some regions, the geologically older shales appear to be more radioactive than the younger shales.

Radioactivity logging equipment. Methods have been devised for determining in the laboratory, the relative degrees of radioactivity displayed by core samples taken during the process of drilling wells. However, a less expensive and more complete log of radioactivity exhibited by formations penetrated during the course of drilling, may be obtained by traversing the well with an instrument sensitive to radioactive gamma rays. This is essentially an ionization chamber, suspended on a co-axial cable that carries electrical impulses to the surface where their magnitude is automatically recorded. The logging instrument is contained within a steel cylinder about 9¾ ft. long and 3⅝ in. in outside diameter, closed at each end against the well fluid. The lower portion of the cylinder is the ionization chamber. It is filled with a gas of high molecular weight (such as "Freon," a compound derived from methane, containing chlorine, fluorine, and carbon) and is fitted with insulated electrodes connecting externally with a source of direct-current electricity. The upper part of the instrument contains batteries that supply current to the ionization chamber, and an amplifier of special design. Current flows through the circuit only when the ionization chamber is brought within the influence of gamma ray emissions from radioactive substances. A measurable current, proportional to the intensity of the radioactive emanations, then flows through the gas between the electrodes of the ionization chamber. This is of the order of one ten-trillionth of an ampere, and must be greatly amplified by the instrument before it may be transmitted through the suspending co-axial cable to the surface. In surface apparatus, the electrical impulses are further amplified before they can be recorded on a scale that clearly reflects variations in the radioactivity of the formations logged. Changes in the magnitude of the amplification may be made from time to time to magnify small variations in intensity of the radioactivity record, which may result when unusual thicknesses of steel casing or cement are interposed between the logging instrument and the formation.

The equipment sent to the well includes two motor trucks: an instrument or recording truck and a truck carrying a winch on which the cable is wound. At the wellhead, the cable passes over an accurately calibrated depth-measuring reel, which is connected through a Selsyn transmission system with a depth-recording device in the instrument truck. A pen on the recording instrument fluctuates with the intensity of the current received from the logging instrument in the well, and draws a log on a moving chart that is synchronized in its movement with the depth-recording instrument. In making a log, the instrument is lowered to the bottom of the well and then hoisted toward the surface at a uniform rate averaging about 1500 ft. per minute. However, the speed of travel of the instrument is varied according to the character of the formations logged and the amount of detail desired. Graphic radioactivity logs drawn by the recording instrument may be made on a scale of either 100 ft., 50 ft. or 20 ft. per in. Fig. 1 reproduces a portion of a typical radioactivity log.



(Courtesy Lane-Wells Company)

Fig. 1. Portion of a typical radioactivity log

Interpretation of radioactivity logs. Radioactivity logs are continuous profiles displaying variation in the gamma ray intensity of radioactive emanations relative to depth. This intensity varies with the lithologic character and content of radioactive material of the formations. In interpreting radioactivity logs, it should be kept in mind that the recorded variations in lateral position of the radioactivity profile are only relative and lack quantitative significance. There are problems incidental to drift of the entire record laterally, resulting from variations in temperature and other conditions affecting the instrument, and problems incidental to the degree of amplification employed, that preclude any quantitative interpretation of the record—at least in the present state of development of the method. Within a distance of perhaps 50 ft. from the surface of the earth, cosmic rays from the atmosphere produce about the same effect upon the ionization chamber of the logging instrument as do the gamma rays from the adjacent rock masses; hence, radioactivity logs are meaningless until this depth has been reached. This is of little importance, however, for the oil producer is seldom interested in logs until well depths considerably in excess of 50 ft. are attained.

If the radioactivity profile swings toward the right side of the record, it indicates that at this depth on the log scale, the clay or shale content of the formation has increased. If it swings to the left, the formation contains less clay or shale than the interval below. Intervals on the profile characterized by comparatively low radioactivity values are probably made up largely of sand, sandstone or limestone strata. Intervals of comparatively high radioactivity value are probably composed largely of shale or clay strata. The profile is thus made up of peaks of high radioactivity, representing shale or clay bodies and valleys of low radioactivity representing sands, sandstones, or limestones. Radioactivity logs closely resemble in appearance, the self-potential profile of an electrical log. Unlike the electrical log, however, the radioactivity log affords no direct basis for estimating porosity or permeability of the formations logged, nor the character of the contained fluids. Indirectly, it is of course possible to infer that an increase in the clay or shale content of a formational interval means smaller percentage porosity and lower permeability, and vice versa.

Alternations of shale and sand bodies and variations in their thickness in a certain formational interval, often pro-

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From the Files of a Major Operator:

THE OLD METHOD

WELL "A"

Location: South Louisiana
Date Drilled: 1941
Total Depth: 9000'
Cores: Conventional; every other ten feet.
Drilling Cost: $105,000.00

THE MODERN METHOD

WELL "B"

Location: South Louisiana
Date Drilled: 1941
Total Depth: 9800'
Cores: None—Electrically logged and side wall sampled by Schlumberger
Drilling Cost: $65,000.00

The above comparison of drilling costs reflects a high percentage of saving due to the very favorable conditions encountered in South Louisiana where oil may be found from "grass roots" to any depth. In territories where more definite objectives exist an average saving of 25% should prove conservative.

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Originators of Electrical Well Logging

duce a characteristic pattern on the radioactivity profile that identifies the interval, so that where the beds are continuous over an area, dependable correlations may be made between different wells in that area. It has been demonstrated that in some regions it is possible to correlate certain formations in wells many miles apart, by comparison of these characteristic patterns developed in the radioactivity profiles. Radioactivity logs will often indicate minor shale "breaks" only a foot or two in thickness in a body of sandy material, thus affording a dependable basis for locating useful reference horizons that might not be made apparent in other systems of logging. Unconformities and fault planes, presenting marked changes in lithology within a short distance, are often distinctly marked on the radioactivity log by nearly horizontal deflections of the profile. Location of the bottom of a cement plug or position of the lower end of a column of casing are usually indicated by an abrupt shift of the profile to the left. The top of a cement plug is usually marked by a gradual drift to the right. Reference points of this character can be located within a foot or two, and this constitutes one of the interesting applications of the radioactivity log.

Though steel casing and cement screen the radioactivity emanations from the formation to a certain extent, satisfactory radioactivity logs may be made through several strings of casing or several inches of cement, that do not differ materially from logs made in the same well before the casing and cement were installed. The log made in open hole shows somewhat more detail and slightly better differentiation between shales and sands. Fluid in the hole surrounding the logging instrument, or in the formation — whether water, mud fluid, gas or oil—has no effect upon the result.

Utility of radioactivity logs. Ability of the radioactivity log to reflect the lithologic character of the formations through casing, readily suggests its most useful application: that of identifying prospective oil sands through casing in wells that have previously been drilled and cased to produce from a lower horizon. In many cases, such wells were drilled before electrical logs were known, and no accurate records of other kinds were made to indicate the positions of oil sands "passed up" or unrecognized during the drilling period. In many such instances, prospective oil sands have been located by radioactivity logging through casing in wells previously producing from greater depths; and on perforating the casing, the sand intervals indicated have been found to be commercially productive. In this service, the radioactivity log has no recognized competitor.

One of the principal fields of usefulness of radioactivity logs will probably be found in making engineering studies of partially depleted oil fields for prospective secondary recovery operations. In the older fields, it is seldom that the earlier records provide sufficient information concerning the detailed stratigraphy of the producing formation to make intelligent provision for control of secondary recovery operations. Often the producing formations are cased off behind a perforated liner or screen pipe. Without disturbing the well casing and screens, the radioactivity log may be successful in procuring a detailed stratigraphic record of the alternating strata of sands or limestones and shales that make up the producing interval in the well.

In addition, the radioactivity log finds a field of usefulness in checking stratigraphic depths carelessly or inaccurately logged in earlier drilling. Dependable information relative to character and thickness of strata cased off in old wells, may thus be made available, and new light brought to bear in the solution of hitherto confused correlations and stratigraphic relationships.

Gamma ray logging not to be confused with "neutron logging." Radiation phenomena afford other methods of approach to the problem of logging formations exposed in wells than the method discussed above, which involves direct observation of the magnitude of emissions of gamma rays. Another method known as "neutron logging," has lately been under development, but has not yet attained widespread field application. The neutron, one of the fundamental components of matter, is liberated by atomic dissociation. Bombardment of the formation in the wall of a well with a stream of neutrons generated by an instrument containing radioactive material (such as a mixture of radium and beryllium), results in emission of gamma rays from the solid portion of the rock mass, the magnitude of these emissions being determined with the aid of an ionization chamber such as that described above. It is believed that the neutron method may be helpful in providing a means of indicating the porosity and character of fluid content of formations behind casing. Due to a peculiar action of hydrogen nuclei in influencing the movement of neutrons, the method may be successful in detecting the presence of hydrocarbons in the formations logged.

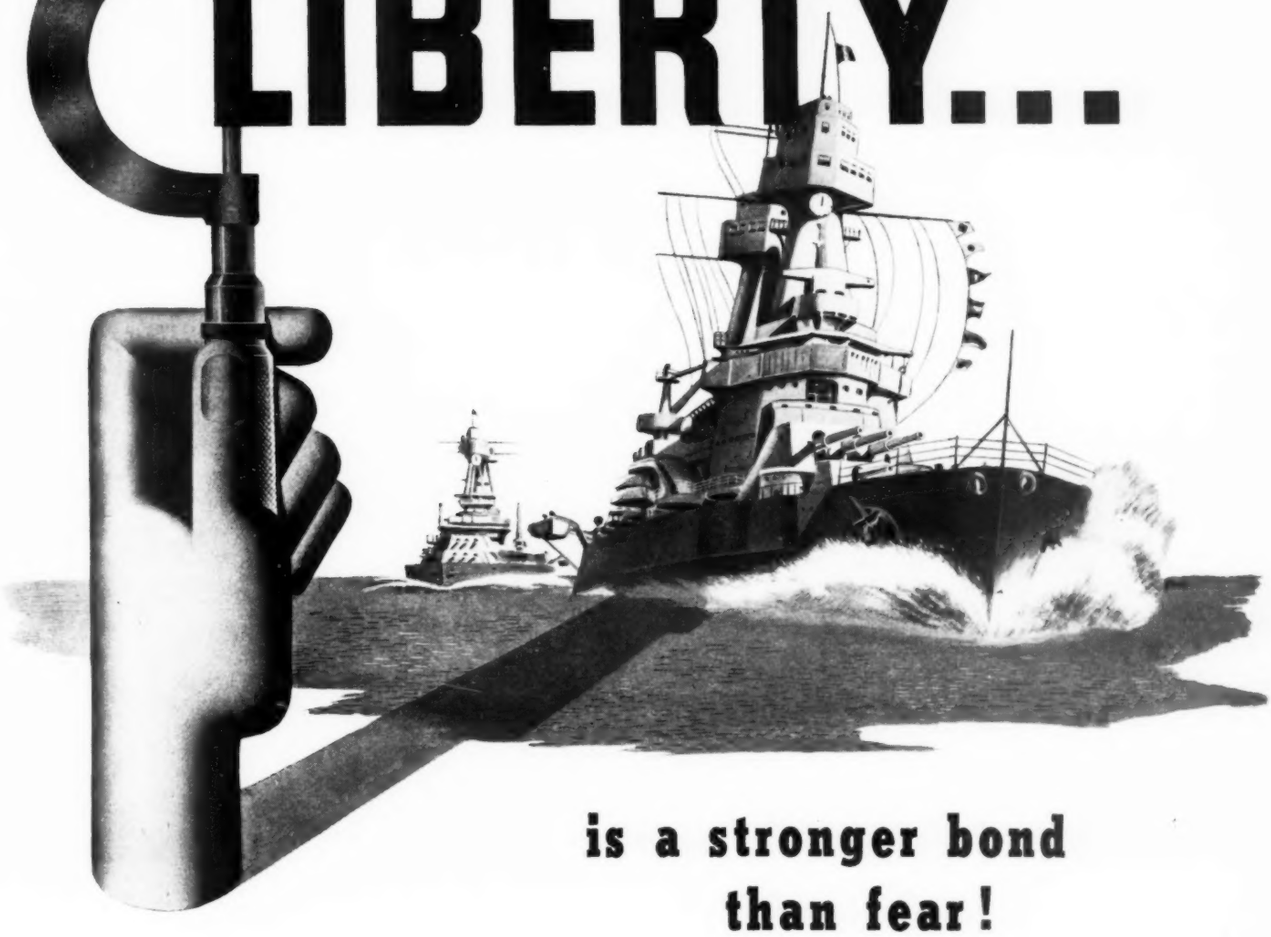
Subsurface radioactivity studies an interesting field for future research. The whole science of radiation is so new that comparatively few engineers are familiar in any adequate degree with its fundamental principles. In the field of experimental physics it is today one of the most prolific avenues of research, and knowledge of radiation phenomena is rapidly unfolding. The petroleum engineer will do well to familiarize himself with what has lately been accomplished in this field, and to keep abreast of new developments in it. Only by so doing may this new and useful tool—the radioactivity log—attain its maximum usefulness in oil-field development. We must not only learn to understand the principles upon which the detecting instruments are based, but we must learn to interpret the records that they produce in terms of stratigraphy, lithology, and fluid content of strata. The origin of radioactive emissions and the processes of sedimentation by which they are concentrated in certain types of rocks and excluded or dissipated from others, and the factors that influence their preservation through long periods of geologic time, are still a virgin field of research. It is a fair assumption that the years ahead will contribute much to our knowledge of these matters and to the utility of the radioactivity log.

Geochemical Well Logging

The chemist has contributed much to the science of petroleum technology. One of his most recent contributions is a new system of well logging known as "geochemical well logging." In this procedure, formation samples systematically gathered in the course of drilling are subjected to delicate methods of chemical analysis that quantitatively indicate the presence of minute quantities of hydrocarbons, hydrogen, and other components. The amounts of these constituents, plotted graphically against a depth scale, often develop characteristic patterns that are found to be indicative of the presence of oil and gas accumulations in underlying or near-by formations. Geochemical logs thus develop data which, when intelligently interpreted, provide a means of predicting the probable success or failure of a drilling operation before it is completed. Providing a direct means of determining the presence or absence of hydrocarbons in formations ahead of the drill, they may be of great value in petroleum exploration and oil-field development.

Theoretical basis for geochemical well logging. Although geochemical well logging depends primarily upon information supplied by the chemist, intelligent interpretation of the log data requires geologic skill and understand-

LIBERTY...



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The answer is that Liberty is a stronger bond than fear. Its authority springs from the free consent of the governed, while the authority of the Axis ideology is the will of gangmen who use their usurped power to enslave the masses.

Free men have always been better fighters; they are better fighters in this war. They go into battle with an undefeatable determination to save the one possession human beings desire above all others—liberty. The initiative and resourcefulness that liberty engenders in free men is manifested in the invention, quick adaptability to new requirements, and astounding production of free enterprise here in America.

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ing. The modern concept of an oil or gas accumulation concedes that the overlying sediments are not capable of completely sealing the fluids in the reservoir rock: that within geologic time subsequent to accumulation of the deposit, slow migration of hydrocarbons through the overlying sediments has resulted, in many cases, in formations all the way to the surface displaying minute quantities of hydrocarbons and their decomposition products.

Even samples of soil gathered about the surface of the earth above the oil deposit, often contain minute amounts of hydrocarbon that can be detected by delicate methods of chemical analysis. When systematically sampled and quantitatively analyzed, such surface accumulations often disclose a "halo" of hydrocarbons in the surface soils surrounding the oil deposit, with lesser amounts in the area immediately above. Apparently diastrophic forces or little understood geochemical effects incidental to upward migration of fluids, results in formation of more indurated and less permeable formations immediately above the oil deposit. Ideas concerning the subsurface paths of escaping hydrocarbons through the formations overlying oil and gas deposits are largely a matter of opinion based on theoretical concepts, and some geologists familiar with the vagaries of sedimentary stratigraphy, question whether there can be any general pattern that would apply to all or even a majority of structures. Yet, study of the results of geochemical logging do support the theory—in many cases at least—that distribution of the hydrocarbons in the formations above and about oil fields follow some recognizable pattern.

Formation sampling and chemical analysis. Formation samples are gathered at intervals ranging from 10 to 180 ft. of well depth, depending upon the amount of detail desired. Usually one sample is taken for each joint of drill pipe added to the drill column, or about every 30 ft. The sample sent to the laboratory for analysis may be a portion of a core, or a representative collection of drill cuttings gathered from the mud ditch or vibrating screen and washed free of drilling fluid. A minimum of about 100 grams of material is necessary for a complete analysis, which requires about five hours of laboratory work. However, several analyses may be conducted simultaneously. Samples should be as fresh as possible and are preferably kept moist during shipment from the field to the laboratory. If a properly equipped laboratory is not within convenient shipping distance, a trailer laboratory containing the necessary analytical equipment may be stationed at the well.

A complete chemical analysis of a formation sample for geochemical logging purposes, includes determination of the percentage by weight, of (1) hydrogen; (2) total hydrocarbons; and further classification of hydrocarbons under three headings: (2a) methane; (2b) gaseous hydrocarbons (methane through butane); and (2c) distillate hydrocarbons (pentane through decane). The amounts of these components are determined by highly sensitive methods and apparatus capable of detecting one part in a billion by weight. Additional components determined by analysis of the formation samples may be (3) carbonates (undifferentiated carbonates and bicarbonates); (4) sulphates; (5) halides (undifferentiated chlorides, bromides and iodides); and (6) acid-soluble sand.

In the course of the analysis, some hydrogen is often evolved. Though its source has not been clearly determined, its presence is believed to be correlated in some indirect way with the presence of hydrocarbons in underlying sediments. The quantity of "gaseous hydrocarbon" shows the summation of amounts of hydrogen ordinarily present in natural gas. The amount of methane included in this is separately reported because of the possibility that it may be indigenous to the sediments in which it is found, hence not significant as an indicator of oil or gas in underlying formations. The "distillate hydrocarbons" are those normally included in natural gasoline. Other properties mentioned above, which may or may not be included in the analysis, are not considered of diagnostic value in indicating the presence of hydrocarbons, but are of value in lithologic studies and classification and correlation of the rocks comprising the strata penetrated and of their contained fluids.

Method of graphically displaying the log data. Results of the chemical analysis of the formation samples are plotted as separate profiles, side by side on a uniform vertical scale of depth, so that they can be directly compared. (See Fig. 2.) The logs are normally plotted to a scale of 1 in. to 500 ft., which permits of convenient overall inspection and comparison of the several profiles. An enlarged scale of 1 in. to 100 ft. is used for more detailed studies. The logs are posted from time to time while drilling is in progress and as the data become available. Properly interpreted, they may thus serve as a guide in planning for deeper drilling.

Interpretation of geochemical logs. The hydrocarbon logs often display characteristic depth patterns. The amount of total hydrocarbons may gradually increase with depth until, when the oil-producing formation is approached, a rapid increase is noted. (See Fig. 2.) The hydrogen log characteristically shows gradual increase with depth, until a maximum is reached some distance above the oil-bearing formation — perhaps many hundreds or even a thousand feet or more—and then abruptly diminishes. The magnitude of the maximum values of total hydrocarbons and hydrogen and the relative depths at which they characteristically appear, vary with the position of the well on structure, and are an expression of the paths of escape of hydrocarbon gases and vapors from the oil deposit.

If the productive formation contains oil, a substantial percentage of the hydrocarbon components will appear as "distillate hydrocarbons." If it contains only gas, the hydrocarbon constituents will be primarily methane and "gaseous hydrocarbons." If the log shows rapid increase in hydrocarbon content, the prospects for finding commercial production in formations immediately below are considered good, especially if a characteristic hydrogen profile has been logged at shallower depth. Thus, it may be possible to predict the proximity of a producing formation with some certainty when the bottom of the well is some distance above—even several hundred feet in some cases. With such information, plans may be made in advance for setting casing, coring and formation testing. The geochemical log gives insurance against premature abandonment of wells and the operator may be encouraged to drill deeper than he had originally intended, with the prospect of finding production from a lower source. The owner of the well may be encouraged in making additional lease commitments, even before a test well is completed.

If the log shows erratic hydrocarbon and hydrogen values or no consistent trend, it is considered an adverse indication. Dry holes customarily display nothing but low values. Thus, the operator may be justified in abandoning operations at shallow depth and a considerable sum saved that otherwise would be wasted in useless drilling. If the "total hydrocarbon" profile shows high values, reaching a maximum shortly below a well-defined peak on the hydrogen profile, then diminishes abruptly as greater depth is attained, but commercial production is not found, it may be inferred that the well is somewhat "off structure" and that production may be found in the vicinity, farther up dip. Where a multi-zone situation exists, with several productive sands at different depths, the hydrogen and hydrocarbon profiles may show

Baash-Ross News

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PETROLEUM ENGINEER EDITION

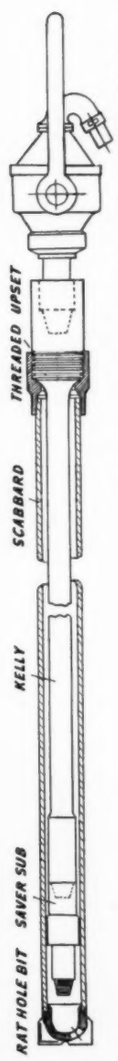
4 VALUABLE TIPS!

For Prolonging the Life and Maintaining the Straightness of Your BAASH-ROSS KELLY!

Your kelly represents a sizeable investment in top-grade, hard-to-get alloy steel. Protect it against damage and abuse by following these simple steps when hauling, racking and using it. They will help lengthen kelly life and enable you to get more value, more service from your kelly investment...

1ST MAKE SURE YOU HAVE A SCABBARD FOR EACH KELLY

A Scabbard is easily made from a section of extra heavy casing, just large enough to accommodate the kelly. At left is suggested arrangement of a unique double-duty scabbard. Kelly upset is threaded to hold the scabbard in place while transporting and storing. Wing blades welded to bottom permit drilling a rat-hole with scabbard and kelly assembled... then scabbard is used for casing the rat-hole. While kelly is in service, the special adapter (see below) is placed at top of scabbard to support bushing and protect threads when kelly is lowered into rat-hole. When moving to a new location, kelly is simply screwed into scabbard and whole assembly is moved as a unit.



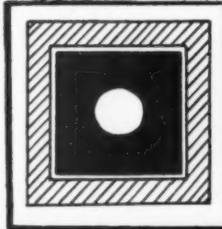
Left: Special adapter connects to Scabbard for supporting kelly bushing and protecting scabbard threads when kelly is low...

2ND ALWAYS KEEP KELLY IN SCABBARD WHEN NOT IN ACTUAL SERVICE

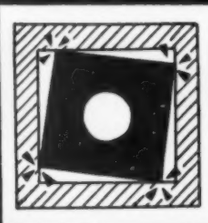
Leave kelly in scabbard until assembly is hanging vertically in rig. Then unscrew scabbard and support it in table while removing kelly for use. Conversely, insert kelly vertically into scabbard BEFORE laying assembly down on walk. Probably more kellys are bent by laying them down or picking them up from cat-walk without protection of scabbard than in any other way... and a bent kelly is practically useless for modern drilling operations. And never drop a kelly into or pull it out of the rat-hole too fast. Dropping the kelly on bottom of rat-hole can easily kink it... and pulling it out too fast will cause severe bending strains. Also, be sure to dig your rat-hole deep enough to accommodate the kelly without excessive "overhang" of swivel. Weight of swivel, unless closely supported, can cause bending.

3RD KEEP KELLY BUSHING TIGHT

A sloppy kelly bushing means that driving forces are concentrated at the kelly corners... causing excessive wear at these points and tending to round off the kelly. But with proper fit, driving pressure of kelly bushing is evenly distributed over a greater area, insuring longer life and increased operating efficiency. This precaution is important on all types of kellys and is particularly vital on hexagonal kellys. But if you are using a Baash-Ross Roller Kelly Bushing with your hex kelly, you will find it easy to maintain proper adjustment by simply removing shims to take up extra play—a valuable construction feature.



Correct fit distributes driving pressures.



Sloppy fit concentrates pressures at corners.

4TH USE SAVER SUB TO TAKE THREAD WEAR

Too many operators still make and break connections at the kelly thread. Install a "saver sub" between kelly and drill string, then make and break connections at this sub, saving thread wear on kelly. It's always easier—and *safer*—to send the sub into a shop for re-threading than to send in the kelly... and you won't lose the use of the kelly if you keep a standby sub at hand to substitute while the other is being re-threaded.

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a separate "echo" for each, and superimposed values may lead to complex profiles difficult of interpretation.

Geochemical logging worthy of more widespread use. The technique of geochemical well logging is a comparatively recent development and its use is not as yet widespread. Although there may be differences of opinion concerning matters of interpretation and validity of theories upon which interpretations are based, it is nevertheless true that the anomalies recorded in the geochemical log have a certain degree of diagnostic value, not only in petroleum exploration, but also in field exploitation. Variations in the amount and kind of hydrocarbons, hydrogen and other significant components in formations overlying and surrounding petroleum deposits, as disclosed by geochemical logs, should be a matter of scientific interest and value to the geologist in interpreting the lithologic and stratigraphic conditions, and should be particularly useful in interpreting the results of wildcat drilling, and in planning development in newly discovered producing fields where the limits of production have not yet been determined. The cost of geochemical well logging service is not excessive ($10 per sample) and the information that it provides may be worth many times the cost. It would seem probable that operators may employ the method more widely in the future than in the past and present.

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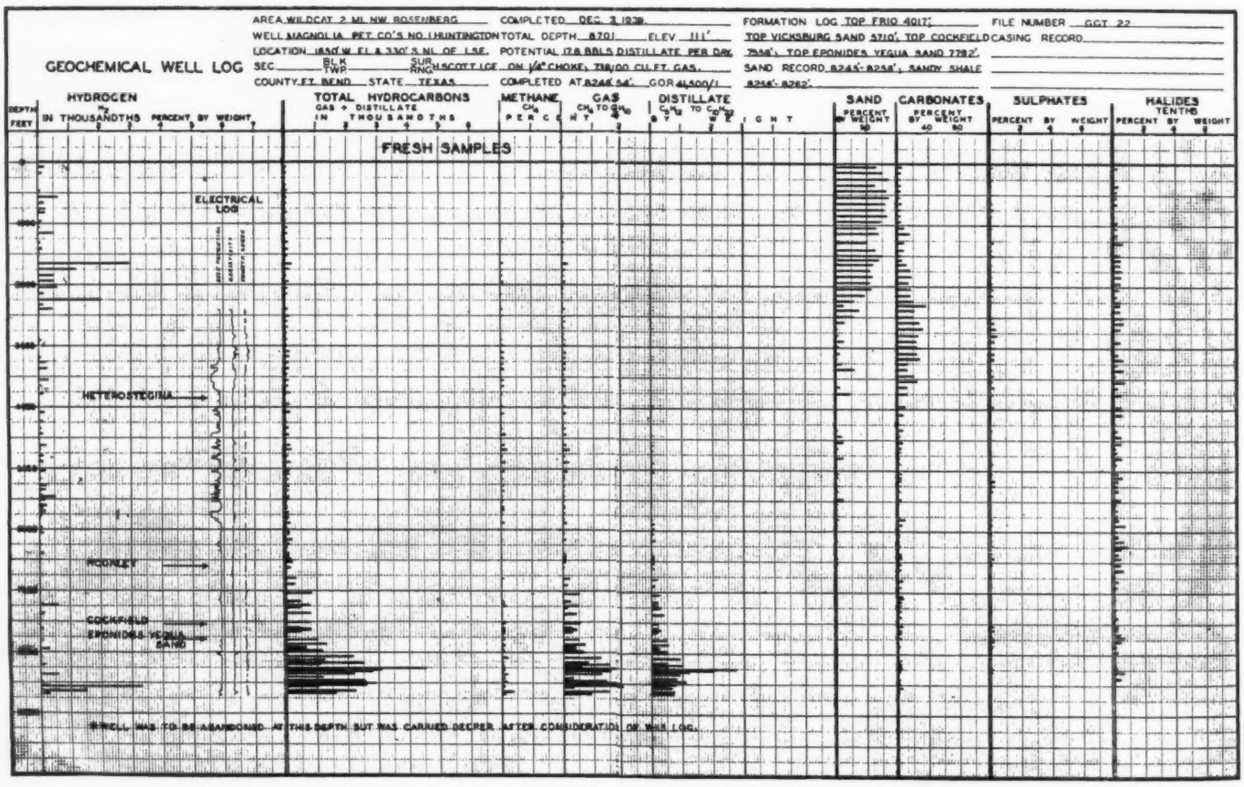
☆ ☆ ☆

Fig. 2. A typical geochemical log of a producing well

(After E. E. Rosaire in Bulletin of A.A.P.G.)


GEOCHEMICAL WELL LOG
AREA WILDCAT 2 MI. NW ROSENBERG
COMPLETED DEC. 3 1938
WELL MAGNOLIA PET. CO'S NO. 1 HUNTINGTON
TOTAL DEPTH 8701
ELEV 111'
LOCATION 1650' W. EL & 330' S. NL OF LSE.
POTENTIAL 178 BBLS DISTILLATE PER DAY
SEC. BLK TWP SUR
RNGH SCOTT ICE ON 1/4" CHOKE, 738/00 CU. FT. GAS,
COUNTY FT. BEND STATE TEXAS
COMPLETED AT 8246'-54'
GOR 41,500/1
FORMATION LOG TOP FRIO 4017'
TOP VICKSBURG SAND 5710', TOP COCKFIELD 7536', TOP EPONIDES YEGUA SAND 7782'.
SAND RECORD 8245'-8258', SANDY SHALE 8256'-8262'.
FILE NUMBER GGT 22
CASING RECORD
DEPTH FEET
HYDROGEN IN THOUSANDTHS PERCENT BY WEIGHT
TOTAL HYDROCARBONS GAS + DISTILLATE IN THOUSANDTHS
METHANE CH_4 PERCENT
GAS CH_4 TO C_5H_{12}
DISTILLATE C_5H_{12} TO $C_{10}H_{22}$
SAND PERCENT BY WEIGHT
CARBONATES PERCENT BY WEIGHT
SULPHATES PERCENT BY WEIGHT
HALIDES TENTHS PERCENT BY WEIGHT
FRESH SAMPLES
ELECTRICAL LOG
HETEROSTEGINA
ROCKLEY
COCKFIELD
EPONIDES YEGUA SAND
WELL WAS TO BE ABANDONED AT THIS DEPTH BUT WAS CARRIED DEEPER AFTER CONSIDERATION OF THIS LOG.

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Storage of Liquefied Petroleum Gases

☆ **Regulations governing tank construction; proper gauging, and safe operating practices important considerations**

by Harry E. Chambers

Superintendent, Lyman Gasoline Plant, Skelly Oil Company

IN THE storage of liquefied petroleum gases there are not many problems considered difficult from the viewpoint of the manufacturer of these gases. Specifications for liquefied petroleum gases require that they be free from moisture and of corrosive impurities; thus the corrosion problem in storage is eliminated. So long as the products stay within these specifications of no moisture and no corrosive impurities the tanks may remain clean. Tanks that have been in service almost 20 years are as clean as when installed.

There have been many improvements in storage tanks, from the riveted to the all-welded construction, in the types of heads used, and the building of larger size tanks.

The purchaser of a storage tank for liquefied petroleum gases can be guided by the specifications of the Bureau of Explosives, the recommended regulations by the National Board of Fire Underwriters, the A.S.M.E., the A.S.M.E.-A.P.I. code for unfired pressure vessels, or the Bureau of Marine Inspection and Navigation. These regulations should be sufficient to provide specifications for containers for any use, storage, transportation, or supply. There are some differences between the A.S.M.E. and the A.S.M.E.-A.P.I. codes, but the A.S.M.E.-A.P.I. code was particularly designed for pressure vessels for the petroleum industry and its products, so that specifications for new tanks should recommend this code. The purchaser need not know all the code specifications for his tank, as numerous tank manufacturers are qualified to build his tank to A.S.M.E. or A.S.M.E.-A.P.I. specifications. The tank should have a name plate attached or stamped on the tank showing the A.S.M.E. symbol with the manufacturer's name, maximum allowable working pressure and temperature, and manufacturer's serial number. It should also be stamped with the water weight capacity either in pounds or gallons. If the tank is for a delivery or transport truck, or for service in which accurate measurements of the contents or delivery of contents are to be made, a certified measurement with strapping of the tank should be obtained from the manufacturer. Also,

HARRY E. CHAMBERS

attended Utah Westminster College, University of Pennsylvania, and graduated with a chemical engineering degree from Ohio State University in 1928—He worked one year as technologist for Harding Glass Company at Fort Smith, Arkansas—Has been with Skelly Oil Company for the last 13½ years in operation and research work, at present as superintendent of the Lyman Gasoline Plant.

a manufacturer's date report for Unfired Pressure Vessels together with a certificate of shop inspection signed by a state inspector or a boiler insurance company inspector should be obtained. Welders must have samples of their welding submitted to test to qualify them for performing the welding of code specification tanks. The manufacturer can supply a report of the test of qualification of his welding operators.

Size of Tanks

Tanks for liquefied petroleum gases range in size from the small tank holding about 2½ lb. of propane that will keep a single burner hot plate in operation about 14 hours to tanks of about 42,000-gal. capacity. Larger tanks are possible, such as the tanks of the East Ohio Gas Company at Cleveland, Ohio, which have approximately 600,000-gal. capacity each. Liquefied natural gas is stored in these tanks at less than 10-lb. pressure, and at temperatures of about minus 250°F. These tanks have been in service about two years. It is reported that this storage is being increased and that special steel is required that will not become too brittle at these extreme temperatures. Also, special welding rod is used in their fabrication. Such storage for butane and propane and their mixtures would not require such extreme subzero temperature, but would range from 30°F. to minus 50°F. A still greater storage is available and is being used for a part of the excess liquefied petroleum gases, that is, the putting of them back into the ground. This is in many cases a part of a repressuring program to increase the oil production of the surrounding wells, one well serving as input well to return butane or propane to the formation. The increased oil production may show a gain of several degrees in gravity. The casinghead gas from the surrounding wells also increases in butane or propane content; there is then more of these products available during periods of increased demand.

Regulations

There are regulations for the maximum size of containers for certain uses. These do not apply usually to the manufacturer's storage tanks at his plant or refinery but some of the restricting regulations are:

The maximum quantity of any liquefied petroleum gas loaded into tanks on one car structure must not exceed 60,000 lb. This would be about 12,600 gal. of butane and about 15,000 gal. of propane. Most of the tank cars are of about 10,000-gal. capacity.

In the recommended regulations of the National Board of Fire Underwriters, which are adopted as regulations in many states, no liquid storage container shall exceed 30,000 standard U. S. gal. capacity as applied to tanks not covered by Interstate Commerce Commission specifications. The same recommended regulations show that no liquefied petroleum gas motor fuel container shall exceed 300-gal. water capacity. It might be assumed, however, that this specification as a motor fuel applies to use in mobile equipment.

Some states have maximum load weights for trucks, which would limit the size of tank permissible for liquefied petroleum gas as the weight of the tank itself would comprise a large part of some of these load limits.

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No underground tanks and none of more than 125-gal. capacity can be situated closer than 10 ft. to a building and recommended regulations provide the varying minimum distances for larger containers.

Such regulations and specifications would indicate the value of checking on any state or local regulations with regard to the size of tanks to be installed, especially if there is any variation from the general local practice.

Regulations that pertain to the tank should be closely checked. Fittings must be properly installed and of suitable material and working pressure, including excess flow valves, safety relief valves, no valves between the relief valves and the tank, and no cast-iron fittings. Specially designed valves for this service are recommended. Many of these valves have composition valve disks, as do the automatic filling and venting connections, and it is very worthwhile to have spare disks, which cost but little, on hand. For propane service 200- to 300-lb. working pressure fittings of steel or brass preferably should be used.

It is generally recommended that at least 5 ft. of liquid head be provided to the suction of a pump. This is of great help when pumping the products. Regulations do not allow a tank to be off the ground more than 24 in. for some types of supports, but supports should be used that permit this liquid head to the pump. Liquefied petroleum gas storage tanks do not require the number of supports usually required of gasoline tanks as the tanks are of heavier steel and when filled to any extent have pressure on them that helps them to hold their shape. Generally two supports are sufficient for a tank, one a few feet from each end. Before the tank is put on these saddle supports, however, it should be given a corrosion-preventive coating, preferably of grease or asphalt base that can be expected to protect the tank for its lifetime.

All electric wiring, lighting fixtures, motors, and switches around such storage should be vapor-proof such as are approved for such installations. Caution signs on all sides should bear the name of the product and the information that the product in the tank is inflammable. It should be fenced with suitable fence, mesh wire, or similar material, a safe distance from the tank. Any loading connections outside the fence should be boxed and locked and these plugged and checked to prevent vapor leaks.

Loading Limits

There does not seem to be as clear an understanding of the loading limits as there should be for liquefied petroleum gases. The Bureau of Explosives has had inspectors on tank car and cylinder shipments in the past who have aided considerably in the proper handling of the products and have promoted the education of all shippers in the proper loading for safe shipment. For the greatly expanded truck transportation of these products that has developed in the last few years this regulation has been missing. Many gasoline plants and refiners who previously had not handled liquefied petroleum gases, found a market by tank truck for their otherwise waste stabilizer overhead residues and loaded tank trucks without knowledge of recommended regulations for safe handling. Excessive vapor pressures were incurred, tanks were loaded too full, and any kind of tank was loaded with no thought of protected fittings, excess flow valves, etc. Manufacturers who had been in the business for some length of time appeared to be the only ones who observed the regulations. Truck drivers had many experiences; such as the one who stopped in town at a restaurant and on looking out saw liquid butane coming from the relief valves of his tank. Other instances were related of relief valves popping as the truck drove down the highway. Fire marshals have been quite interested in knowing more about the safe handling of these products and have related bad practices such as delivery truck drivers venting the customers tank to the air in town when delivering and filling the tank, and of truck tanks that did not conform to safety regulations. Some fire marshals prohibited the passage of butane trucks through the city limits of their town. They were also interested in knowing how to fight a butane fire if they happened to have a truck load dumped into their streets.

Safe Practices

Actually these liquefied petroleum gases if loaded properly in approved tanks with properly protected and approved fittings are as safe to handle, transport, and store as any other petroleum product. Proof of this statement is the fact that a 2500-gal. transport that went over a 30-ft. drop, smashing the truck, did not lose any of the butane. Other tank trucks have been in accidents and wrecks and no butane lost. To the fact that these tanks conformed to code specifications is due a share of the credit.

Cases are known of a farmer coming to a plant and requesting that an ordinary oil drum be filled with butane; also of a dealer who requested that his transport tank be filled with an additional 100 gal. per trip in order to save trips. In each of these cases, as in many others, the manufacturer has enforced the regulations by refusing to comply with the requests.

In shipping these products by tank cars there is considerable calculation necessary to make out the billing for shipping. Tables have been worked out by Skelly Oil Company for outages that apply to all U. T. L. X. tank cars or any others of 85-in. or 87-in. diameter. These give the outage for each degree temperature for each gravity so that the laboratory can give the loader the gravity of the product as determined in storage and the loader can take the temperature when nearly loaded and from his table can immediately set his final outage and complete the loading of the car.

In the office are tables giving the billing weight and the net gallons at 60°F. for all the shell capacities of cars, one page for each gravity. Then the known shell capacity and the gravity of the product in the car are used to obtain the billing weight and net gallons at 60°F. and another copy of the outage table gives the clerk all the information necessary in a much shorter time. Similar tables have been worked out for each truck loading from a plant. An idea that began with truck loading was that tanks should be loaded to 90 percent of capacity. Tank manufacturers built outage spaces on this basis and many liquefied petroleum gas manufacturers loaded their products on this basis. As a great many, if not all, tank trucks are uninsulated, this system overloaded them; they should be loaded on the basis that the tank would not be more than shell full if the temperature of the contents was 130°F. On this basis the propane would be loaded to about 84 percent at 60°F. and to not more than 88 percent at 60°F. for butane.

Repair Leaks Immediately

Many losses of product are reported as shortages that actually are the result of vapor leaks in a system. Leaks that with less volatile liquids would show up as a drip do not appear evident at all so that any noticeable leaks should be repaired at once. Any question of leakage can be decided easily by testing with a good soapsuds solution. Pump packing or valve-stem packing is a common place for leaks; also, hose couplings should be of the best design so they can be easily coupled without leaks, for there is greater hazard if these vapors ignite, then burn the hose, and thus open a greater stream to ignition.

Gauging

Gauging devices chosen for tanks should be considered on the basis of the degree of accuracy desired. Many tanks have been equipped with percentage

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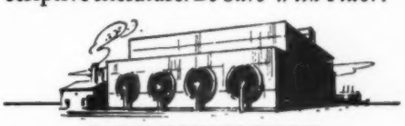

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Under certain conditions Fluor can deliver Forced or Induced-type Mechanical Draft Cooling Towers. There must be a willingness on the part of customers to wait while submanufacturers deliver fans, gears and motors to our plant. They can be delivered only on the highest priority. That's why—for the duration—we recommend the Atmospheric type. In the meantime, Fluor continues with research and development of Mechanical Draft types to give you the advantage of many improvements when the war is over.

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gauges that read on a scale about 5 or 6 in. long to gauge a tank 36 to 40 in. in diameter. The writer has seen gauges that could not gauge to closer than 25 gal. from which 100 to 200 gal. deliveries were expected to be made.

Conclusion

This article has been written with a view to presenting the actual operation of tanks for liquefied petroleum gas, although it cannot be considered to be complete in that respect. Technical data are available and are fairly complete.

The following references will provide reasonably complete regulations and specifications.

"The National Board of Fire Underwriters Pamphlet" No. 58 of Standards of the National Board of Fire Underwriters for the Design, Installation, and Construction of Containers and Pertinent Equipment for the Storage and Handling of Liquefied Petroleum Gases.

"Interstate Commerce Commission Regulation for Transportation of Explosives and Other Dangerous Articles by Freight including Specifications for Shipping Containers." Revised Effective January 7, 1941. From Superintendent of Documents, Washington, D. C.

Handbook, "Butane-Propane Gases," Third Edition. Part 4, Chapter 1—Delivery by Truck, Rail, Water and Pipe Line; Chapter 2—Storage Tank and Pressure Vessel Design; Part 7—Regulations.

A.S.M.E.—Code for Unfired Pressure Vessels.

A.S.M.E.-A.P.I.—Code for Unfired Pressure Vessels.

Gas—November and December, 1940; June, 1941; Natural Gas Liquefaction, July, 1942.

"Interstate Commerce Commission Regulations Applying to Transportation of Inflammable Liquids and Inflammable Compressed Gases." Effective January 7, 1941. B. E. Pamphlet No. 21, published by the Bureau of Explosives, 30 Vesey Street, New York, New York.

"Motor Carrier Safety Regulations—Revised Part 7—Transportation of Explosives and Other Dangerous Articles," by Interstate Commerce Commission. From Superintendent of Documents, Washington, D. C.

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P 934.314.

"Umbrella" Shields Plants From Lightning

A WIRE "umbrella" to shield vital explosives plants and oil storage centers from lightning has been developed by Dr. Gilbert D. McCann, Westinghouse Electric and Manufacturing Company engineer. It is already being used by some war industries and one huge ordnance plant. Using a minimum of strategic materials, the shield easily deflects lightning driving earthward at more than 11,000,000 miles a minute.

The shield consists simply of a steel wire strung above the building to be protected and anchored on tall wooden poles at each end. The wire is then connected to steel rods buried in the ground.

This method saves copper for other war uses. Previously explosives plants or oil depots were guarded by lightning rods, which required about 250 lb. of copper attached to the building and buried in the surrounding ground. An umbrella for the same building can be erected with only 60 lb. of steel and two wooden poles. With the new design danger of lightning leaping to metal sections of the building and causing sparks has been eliminated.

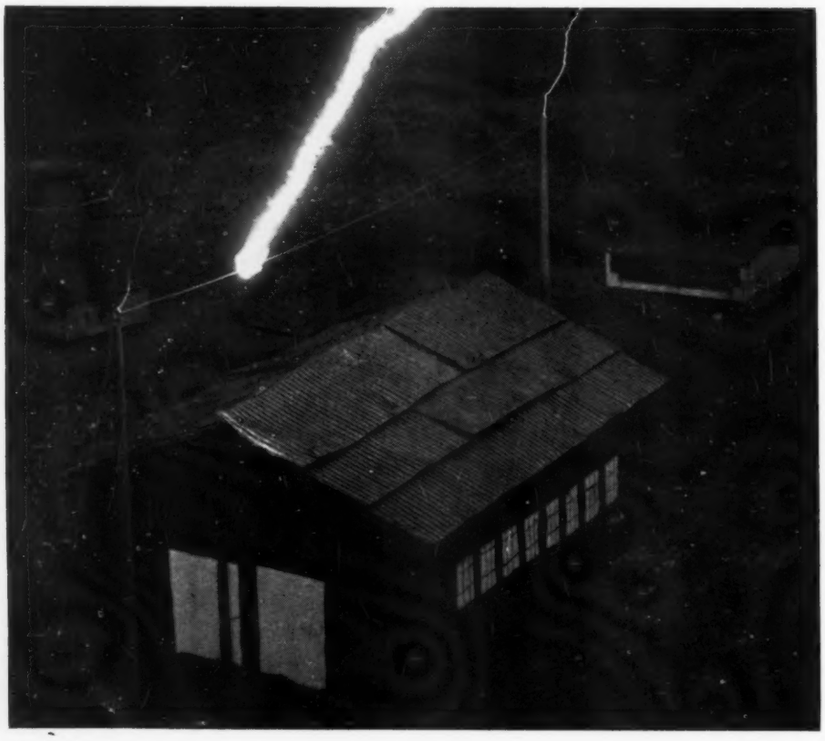
Studies of lightning strokes on power lines show that each square mile of sky hurls about 10 thunderbolts at the ground each year. Modern ordnance plants have several hundred buildings spread over a large area so each plant will be a target for lightning several times a year. Just one of those strokes could cause a disastrous explosion or fire if proper protective devices were lacking.

Another lightning protection plan suggested by Dr. McCann surrounds the building with six poles 10 ft. higher than the roof. Steel wires extending from the top of each pole attract lightning from the area above the structure so that an invisible lightning-proof "blanket" is suspended over the roof. Thunderbolts are drawn to the steel tips of the poles and thence to the ground.

Westinghouse engineers know the character of lightning from data collected in the field by fulchronographs mounted atop fire towers, power lines, and radio transmission masts. Lightning striking these structures is led to the fulchronograph, which has a constantly revolving wheel. On the rim of the wheel are metal blades, which are magnetized by the lightning. The number of blades magnetized and the amount of magnetism in each gives engineers a picture of the thunderbolt.

Lightning strokes sometimes have a peak current of 200,000 amp., enough to supply a city of 50,000 people with electricity momentarily. The electrical pressure in the stroke may be 20,000,000 volts, great enough to blow out 200,000,000 household fuses.

Power line protection methods developed at Westinghouse 12 years ago by the late Dr. Charles L. G. Fortescue, noted lightning expert, guided Dr. McCann in his search for a more efficient way of shielding war plants. Dr. Fortescue improved the method of stringing a grounded wire above the lines to lead direct lightning strokes harmlessly into the earth.



Man-made lightning streaks toward a model explosives plant but is warded off by the wire umbrella devised by Dr. Gilbert D. McCann

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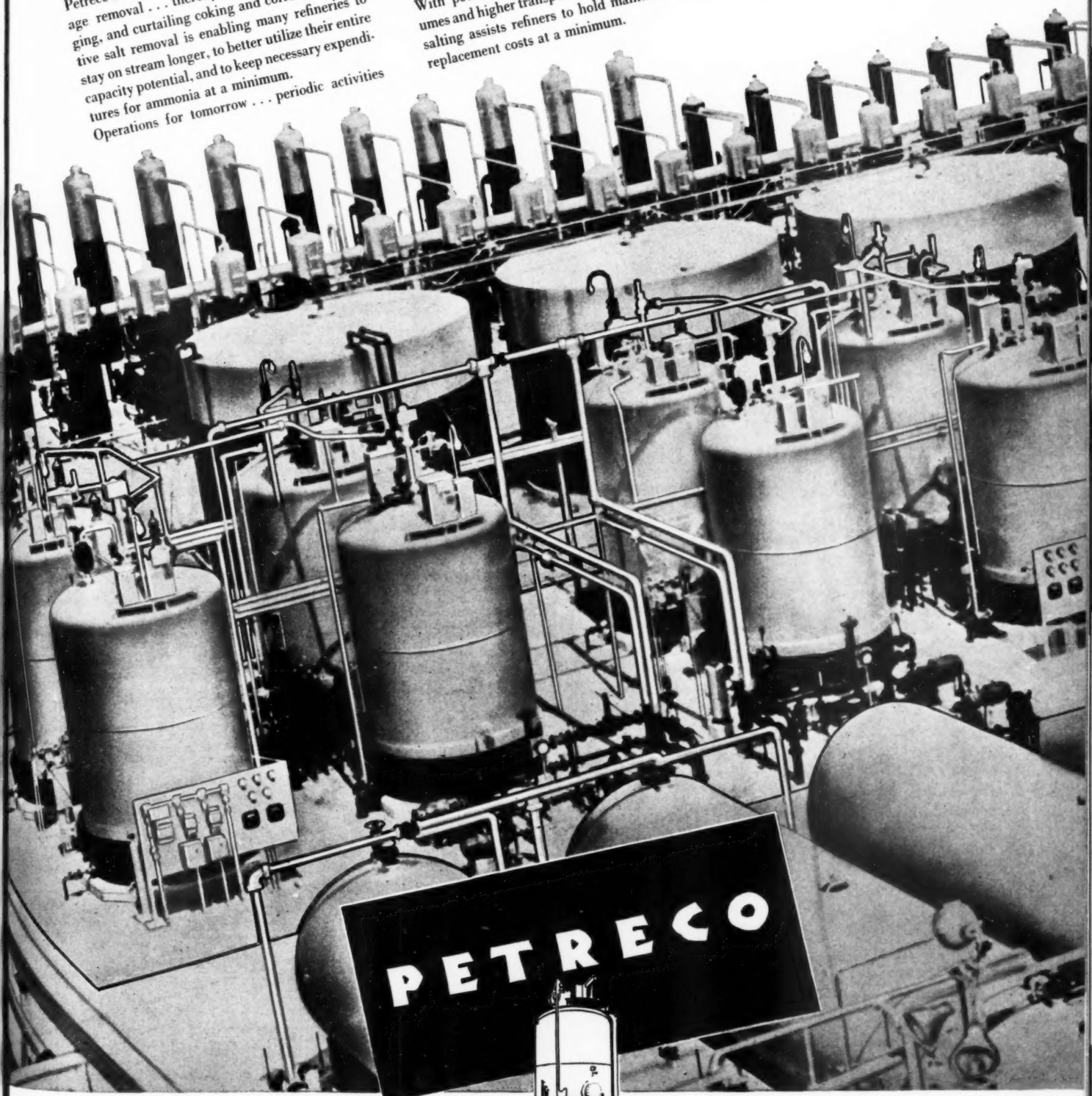


DESALTING DEHYDRATING

Chemical Influences in Drilling Mud Evaluated by Viscosity Measurements*

PETROLEUM ENGINEER Exclusive Feature

☆ Fundamental principles of colloid viscosity used to evaluate forces existing between clay crystals

by Arthur W. McCray
Chemical Engineer, The Pennzoil Company

Drilling Mud: A Colloid System

ONE OF the most important observations ever made on drilling muds is that changes in their properties are interdependent. An example of this occurs when common salt is added to a mud. It becomes more viscous, and may form a gel, and at the same time its ability to form a tough and impervious filter cake is impaired. Such examples lead to the conclusion that certain forces which affect both viscosity and filtration processes must be present in the suspension. The chemicals present influence and largely control these forces. Their evaluation would be a step toward the simultaneous control of various physical properties of drilling muds. This article will present some fundamental principles of colloid viscosity that can be used to evaluate the forces existing between the minute clay crystals in a drilling mud.

In order to understand the origin of the forces acting between clay particles, it is necessary to consider the structure of the clay minerals. There are two main clay minerals, kaolinite (common clay) and montmorillonite (bentonite, widely used in rotary drilling muds). Both develop in plate-like forms, and the edges are breaks in the crystalline structure. Thus, unsatisfied atomic bonds exist at the edges of the clay crystals; and these bonds are satisfied by ions present in the water. If no salt, or acid, or base is present to supply the needed ions, then the bonds are satisfied by hydrogen ions supplied by the water itself. In the latter case, the clay is known as hydrogen clay. If common salt is present in the suspension to supply sodium ions, then the clay is known as sodium clay. If potassium hydroxide is present to supply potassium ions, then the clay would be called potassium clay, and so on.

*This article is a summary of a thesis, "Viscosity and Gelling of Clay Suspensions," submitted by the author to the Graduate School, The Pennsylvania State College, from the Department of Petroleum and Natural Gas Engineering, as partial fulfillment of the requirements for a Master of Science degree. Printed with permission of the Graduate School.

ARTHUR W. McCRAY

received a bachelors degree in petroleum and natural gas engineering from The Pennsylvania State College in 1940 and an M.S. degree in 1942—Before entering college he worked as a roustabout and pumper in the Pennsylvania oil fields—Worked two years in the plant of The Pennzoil refinery—Spent two years in oil-field development work, both around drilling rigs and air-gas repressuring—In 1937 he entered The Pennsylvania State College and was an instructor there in petroleum engineering from 1940 to 1942—He has recently accepted a position with The Pennzoil Company as chemical engineer.

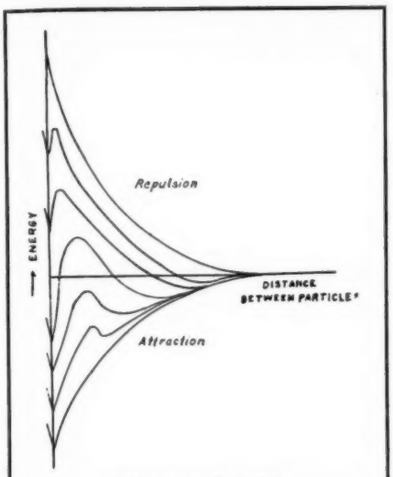
A balance, or equilibrium, exists between the ions associated with clay particles and the free ions in the water. There is a tendency for the ions satisfying the bonds at the edges of the clay crystals to dissociate from the clay. They leave the clay, yet linger nearby so that an overall positive-negative balance is maintained. Any of the same kind of ions existing free in solution in the water repel their kind and drive the ions back to close union with the clay. Accordingly, it can be seen that at some intermediate concentration of ions (or electrolyte) the number of dissociated ions around a clay particle will be greatest. These ions dissociated from a clay particle have a positive charge, and they leave the clay with a net negative charge. Thus a static electrical field is built up around each clay particle, and its characteristics depend upon the nature and amount of electrolyte added to suspension.

The static electrical field surrounding each clay particle is responsible for the forces of attraction and repulsion that exist between the particles These forces were first suspected because of gelling and other static phenomena. Because of the nature of the charge distribution about the clay particles, it is possible, under certain conditions, for two particles to repel each other at certain distances of separation and attract each other at other distances of separation. Theoretical calculations on the possible natures of force-distance curves have been made by H. C. Hamaker.[1] Some of his curves, which show the possible changes brought about by the gradual addition of an electrolyte to the clay suspension, are shown in Fig. 1. Each curve on the diagram is characteristic of a particular batch of mud. In order to get onto another curve, it would be necessary to add some chemical to the mud.

Principles of Colloid Viscosity

True liquids, such as oil and water, have a definite viscosity at any specified conditions of temperature and pressure. This is not ordinarily true of colloids. The previous history of the suspension includes two factors: (1) aging and (2) flow history. By aging is meant the length of time the dry clay has been in water. Clay crystals imbibe water and swell. The exchangeable cations associated with the dry clay must come to equilibrium with the water phase of the suspension. Both of these reactions take time, and it is probable that the time required depends upon the particular clay being used. Flow history is a factor in viscosity because of the gelling nature of clay suspensions. The particles adhere to one another. Under the shearing forces present in a flowing stream, the clay particles are torn away from each other. Again, this takes time. As soon as flow is stopped, the particles begin

[1]Rec. Trav. Chim Pays-Bas, H. C. Hamaker, 55 (1936); 56 (1937) p. 5.



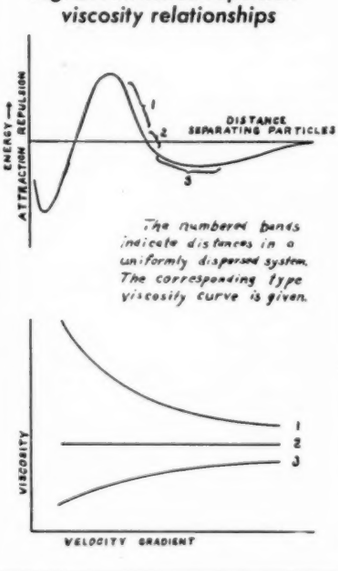
(After H. C. Hamaker)

Fig. 1. Net attraction-repulsion curves where the resultant force is attractive at greater distances and repulsive at shorter distances. Gradual changes in the system are shown

to reunite according to the gel rate of the suspension. However, it is possible by prolonged flow, or shearing, to bring a sample of mud to a dynamic equilibrium. The effects of aging can be largely eliminated by using clay that has been in water and occasionally stirred for about a month.

The rate of flow is almost always a factor in the measured viscosity of a clay suspension. This is more properly termed the velocity gradient; and it is the relative velocity of two flowing layers expressed as feet per second per foot separation between the layers. Thus, its units reduce to 1/seconds or sec.$^{-1}$. It is merely the time rate of flow.

Fig. 2. Attraction-repulsion-viscosity relationships



The function of the velocity gradient itself should be considered before attempting to explain variations in viscosity due to changing the rate of flow. It is axiomatic that, with other conditions being equal, the viscosity of a suspension will depend upon the concentration of solids in the suspension; and this fact is recognized by all formulae derived for the viscosities of suspensions. If a clay suspension in flow is not uniform in the distribution of clay particles, less resistance to flow will occur in the less concentrated portions of the suspension. The faster rate of flow set up in these portions of the suspension will tear away the clay particles from the more concentrated portions of the suspension; and, under very fast rates of flow, this action will give a uniform distribution of the clay particles throughout the suspension. Of course, it is a matter of common experience that a uniform distribution can be effected by stirring. Therefore, the primary function, or tendency, which will be assigned to the velocity gradient acting on a colloid system is that tendency to produce a uniform distribution of the solid particles.

In Fig. 2 are shown the three possible net attraction-repulsion relationships between colloid particles and the corresponding types of viscosity curves. It should be noted that the separation distances between particles refers to the distance between particles in a uniformly dispersed system. Therefore, the horizontal distance from the vertical axis at the left is controlled entirely by the concentration of solids in the suspension; i.e., it is controlled by the pounds of dry clay per cu. ft. of drilling mud, and the heavier the mud, the closer the clay particles will be to one another. The type of curve by which the system may be represented will depend on the chemicals added to the mud.

Case 1. The clay particles repel each other when they are uniformly dispersed. Under flowing conditions the particles cannot remain at uniform distances of separation. The particles in one shear layer overtake, draw closer, pass, and then draw away from the particles in another shear layer. As two particles draw closer together, they repel each other; and both are forced to move sideways, perpendicular to direction of flow. This added movement consumes extra energy. If the rate of flow is fast, the particles pass each other so quickly that very little sideways movement can take place. The kinetic energy of flow is sufficiently great to be efficiently exchanged with the potential energy of relative positions; and a fairly straight-line movement of the particles, which consumes the least energy, is the result. Now it can be seen that a very small (differential) force could cause flow in such a system, but an efficient type of flow could be reached only by using larger forces and higher flow velocities. Accordingly, the viscosity of such a clay suspension will decrease with increasing rates of flow.

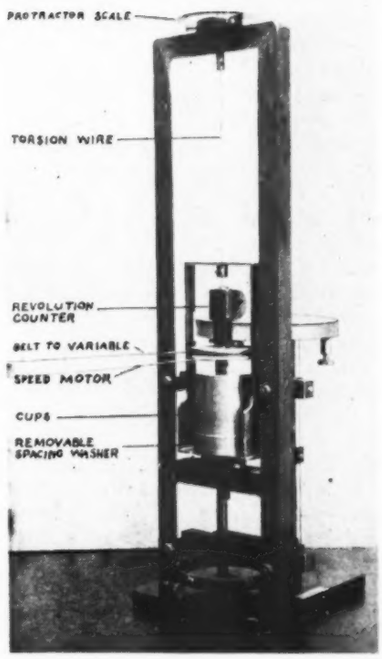
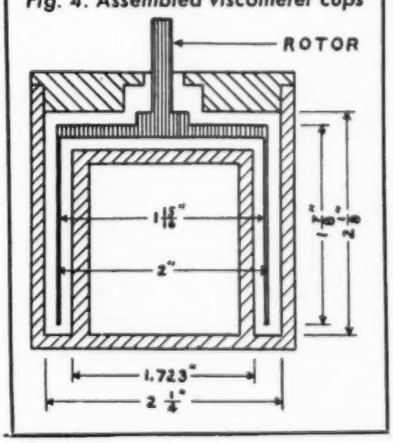


Fig. 3. Photograph of assembled viscometer

Case 2. The clay particles neither attract nor repel each other when they are uniformly dispersed. The viscosity of such a system is essentially independent of the rate of flow. The clay

Fig. 4. Assembled viscometer cups



particles always move parallel to the direction of flow, for there are no forces present to cause them to behave otherwise.

Case 3. The clay particles attract each other when they are uniformly dispersed. The only means of keeping such a system uniformly dispersed is to keep it flowing. Then, when the clay particles alternately draw closer together and then separate, at some distances of separation occurring within the flowing system the particles are drawn closer to each other by their mutual attraction; and they are thus forced to move perpendicular to the direction of flow. However, if the rate of flow is decreased, the velocity gradient is weakened; and the clay particles are permitted to remain nearer to a mean position of separation where there are no strong attractive nor repulsive forces. Viscosity is reduced by two mechanisms. The amount of sideways movement of the clay particles is reduced; and a portion of the water is cleared of colloid particles and becomes free to act as a true liquid flow layer within the system. Thus, in such a system, the internal resistance to flow is lower at slow rates of flow. Viscosity increases with the rate of flow.

Experimental Work

The viscometer used was of the rotating cup type. This type was preferred because a sample could be placed in the viscometer and the cups could be left rotating until the viscosity became constant. As this often took over an hour of shearing at a speed of 400 r.p.m., it is thought that other types of instruments may not give reproducible results. The speed of rotation, which was controlled by a rheostat, was measured by means of a revolution counter and a stop watch. The torque produced was measured by a torsion wire that supported the outer cup. A photograph of the instrument is shown in Fig. 3, and a drawing of the viscometer cups is given in Fig. 4. Calibration of the viscometer was done by using mixtures of motor oil and naphtha, and the viscosities of these mixtures were measured in a capillary tube type viscometer. The formula of the instrument is:

$$n = \frac{110 \text{ Degrees Scale Reading}}{\text{R.p.m.}}$$

where n = the viscosity in centipoises. The calibration data for the viscometer are given on Fig. 5. The slopes of the lines are directly proportional to the viscosity of the oil used in the cups.

Preparation of the clay was carried out by taking 10 lb. of bentonite and leaching it with one-tenth normal hydrochloric acid for three weeks and with distilled water for three weeks. The suspension was stirred each time new liquid was added, allowed to settle, and the following day the clear liquid on top was taken off. At the end of the leaching the clay would not settle out from the suspension. For this reason no determinations of particle size by the hydrometer method were possible. The clay suspension was concentrated by evaporation; and, as the clay was in water for three months before any data were taken, no effects whatever of aging were observed. Samples for viscosity determinations were taken from the prepared batch of clay, thoroughly mixed, and the water was dried out at 110°C. from a small sample in order to determine the weight percent of clay in the suspension. Potassium hydroxide was then added from a burette to give the desired number of m.e. KOH per 100 grams dry clay. The sample was then diluted with distilled water from a burette to reach the desired weight percent of clay in the suspension.

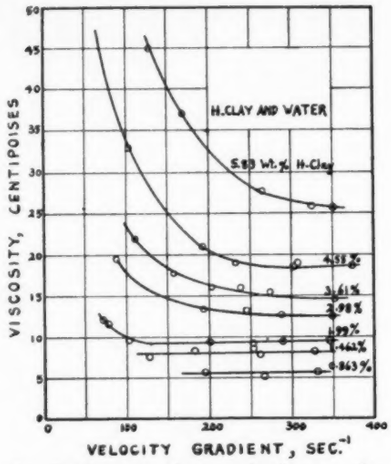


Fig. 7. Viscosity data on hydrogen clay

Discussion of Results

The effect of stirring time on viscosity of a clay suspension is shown graphically by Fig. 6. The viscosity decreases with time and approaches a limiting value. This is a measure of the work absorbed by the colloid system in order to reach a state offering less resistance to flow. Work equals force times distance. On the basis of 1 cc. of material, the force equals $n\frac{dv}{dz}$, and distance equals $T\frac{dv}{dz}$, where n, T, and $\frac{dv}{dz}$ are the viscosity, time and velocity gradient, respectively. Therefore, work per cubic centimeter of material equals $n\left(\frac{dv}{dz}\right)^2 T$. The work absorbed by the system equals $\int T\left(\frac{dv}{dz}\right)^2 dn$. The value of $\frac{dv}{dz}$ was held nearly constant at 330 sec.$^{-1}$. (375 r.p.m.). The value of $\int Tdn$ is the shaded area on Fig.

Fig. 5. Calibration data for viscometer

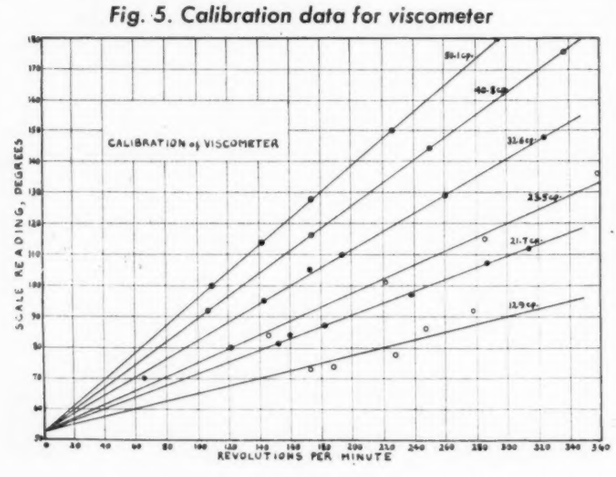
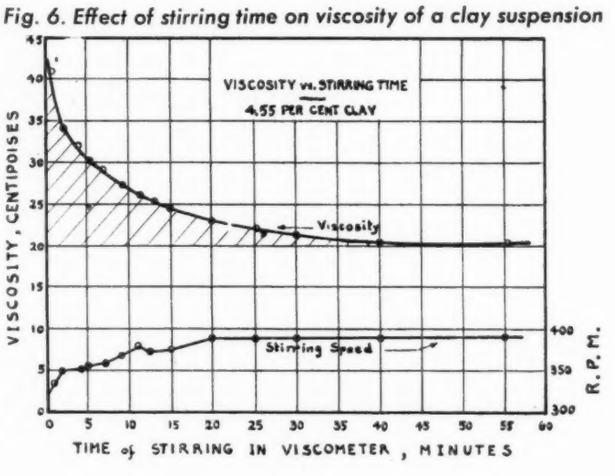


Fig. 6. Effect of stirring time on viscosity of a clay suspension



Announcement

U. S. Patent No. 2,294,877

CHEMICAL TREATMENT OF DRILLING FLUIDS

This is to announce that Baroid Sales Division has obtained from Visco Products Company (sole Licensee under the above patent) the exclusive right to negotiate licenses under the above patent.

The patent covers the treatment of well drilling fluids with the following classes and combinations of chemicals:

1. Water-soluble polyphosphoric acid compounds. (For example, sodium hexametaphosphate, sodium pyrophosphate, sodium acid pyrophosphate, sodium tetraphosphate, certain organic polyphosphates, etc.)
2. Water-soluble polyphosphoric acid compounds in connection with lyophile colloids. (Examples of lyophile colloids are: chestnut extract, quebracho extract, lignins, etc.)
3. Water-soluble polyphosphoric acid compounds in connection with buffers. (Examples of buffers are: soda ash, orthophosphates, etc.)
4. Water-soluble polyphosphoric acid compounds in connection with lyophile colloids and buffers.

Licenses under the said patent are available to Oil Companies and others engaged in drilling wells, on a royalty basis per pound of chemical employed by them in the treatment and use of well drilling fluids in accordance with the said patent, whereby Licensees may purchase the said chemicals from any seller thereof. Under the terms of the proposed License Agreements, which are issued by Visco Products Company, the Licensee has the option of terminating the agreement at any time upon 60 days written notice.

To those who are not thoroughly familiar with the subject of the chemical treatment of well drilling fluids, we should like to point out that Visco Products Company pioneered the development of chemical treatment of drilling fluids, their product "Stabilite" having first been marketed for this purpose in 1930. Baroid Sales Division, as exclusive distributor of the various improved "Stabilites" marketed since that time, takes considerable pride in the fact that it has played an important part in the development of present-day chemical treating methods.

We also wish to announce that, notwithstanding the issue of the patent, there will be a substantial reduction in the price of "Stabilite," effective February 1, 1943.

For complete details of the License, Oil Companies and others engaged in the drilling of wells are kindly requested to communicate with Baroid Sales Division, National Lead Company at 830 Ducommun Street, Los Angeles, California, specifying the particular chemicals they desire to use under the patent.

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STERLING BUILDING
HOUSTON, TEXAS

BAROID SALES DIVISION
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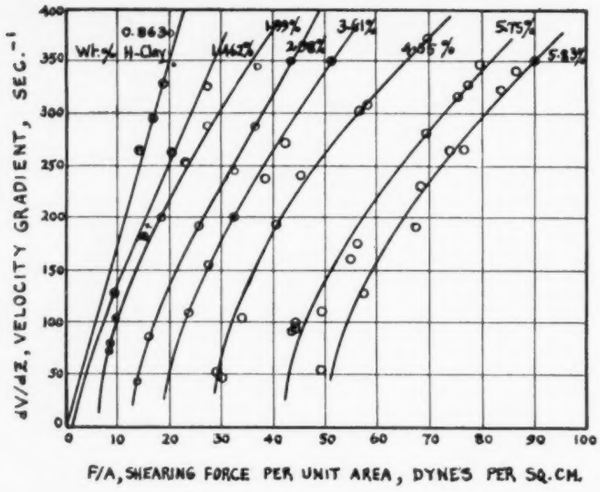
LOS ANGELES, CALIFORNIA



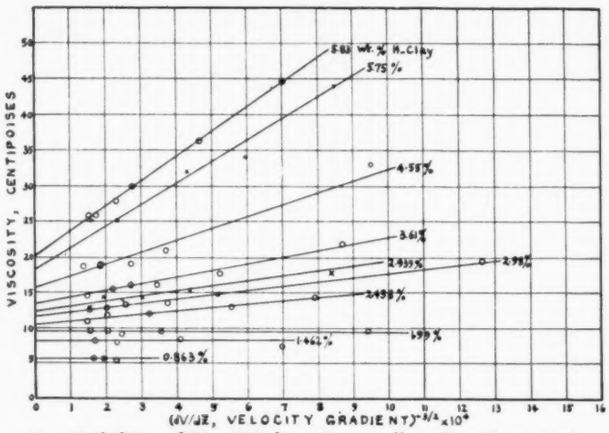


Fig. 8 (left) and Fig. 9 (above) as well as Fig. 7 present viscosity data obtained on hydrogen clay

6, or 112 poises × seconds. Therefore, $\int T\left(\frac{dv}{dz}\right)^2 dn = \left(\frac{dv}{dz}\right)^2 \int T dn =$ (330 sec.$^{-1}$)^2 (112 poises × seconds) = 1.22 × 10^7 ergs per cm^3. This is equivalent to 0.292 calories per cm^3, or an increase in entropy, at 23°C. of 0.0211 cal. per °C. abs. per gram of clay in suspension. This is the increase in the energy of relative positions of the clay particles brought about by stirring.

The viscosity data obtained on the hydrogen clay is presented on Figs. 7, 8, and 9. It will be noted that when the viscosity is plotted versus (r.p.m.)$^{-3/2}$ on Fig. 9 the curves become straight lines. This made possible the development of a formula applicable only to the hydrogen clay in the speed ranges studied, which is:

$$n = 1 + 3.43\ w + 310\ w^{8/3}\left(\frac{dv}{dz}\right)^{-3/2}$$

n = measured viscosity, centipoises
w = weight percent clay in suspension
$\frac{dv}{dz}$ = the velocity gradient, sec.$^{-1}$
= 0.890 × r.p.m., for the viscometer used.

The chemical added to the leached clay in order to vary the charges on the clay particles was potassium hydroxide. The effects of the potassium hydroxide (KOH) on the pH and the specific electrical conductance of the suspension were measured. The results are plotted on Fig. 10.

The viscosity data for 3, 4, and 5 percent by weight bentonite suspensions are given on Figs. 11, 12, and 13. Measured viscosity is plotted versus the flow velocity gradient. The numbers on the curves indicate the number of milliequivalents of potassium hydroxide added to the clay suspension per 100 grams of dry clay. It can be noted that in some cases the viscosity increases with the rate of flow, and in other cases the viscosity decreases with the rate of flow.

On Fig. 14 the viscosity is plotted versus the milliequivalents of potassium hydroxide added per 100 grams of dry clay. The numbers on the curves indicate the particular velocity gradient that the line represents. The data points were taken from the viscosity versus velocity gradient curves. Where a 100 curve lies above a 300 curve, as for both the 4 and 5 percent clay suspensions at 40 m.e. KOH per 100 grams dry clay, the viscosity of the suspension decreases with increasing rates of flow. Where a 300 curve lies above a 100 curve, as for all the 3, 4, and 5 percent clay curves at 20, 80, and 100 m.e. KOH per 100 grams clay, the viscosity increases with increasing rates of flow.

The graph, Fig. 14, indicates that in the case of the particular bentonite used in this investigation, the maximum particle charge occurred when 40 m.e. KOH were added per 100 grams clay. This can be inferred also from the pH curve, for it has an inflection point at the 40 m.e. KOH line. This charge is relatively short ranged in its actions. Note that in the wider spacing between clay crystals occurring in the 3 percent clay suspensions the clay particles attract each other.

In contrasting the viscosity data at the 0 m.e. KOH line, where hydrogen ions from the water supply the charge, to the data at the 40 m.e. KOH line, where the charge is largely from potassium ions, two things are apparent. First, the charge is weaker; and this

Fig. 10. Results of titration of clay with KOH

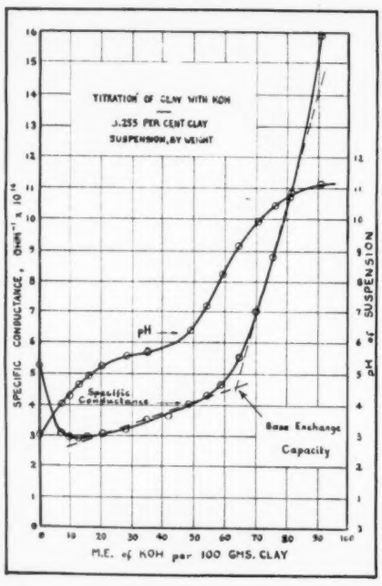
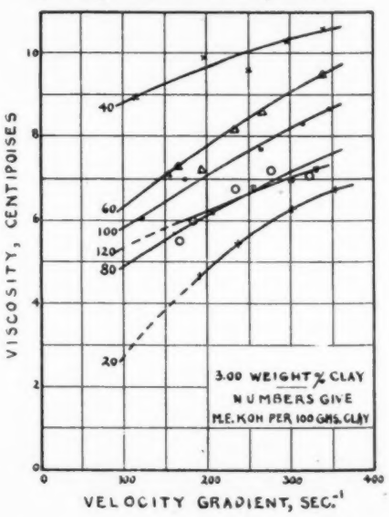

TITRATION OF CLAY WITH KOH
3.255 PER CENT CLAY SUSPENSION, BY WEIGHT
SPECIFIC CONDUCTANCE, OHM⁻¹ x 10⁻⁴
pH of SUSPENSION
pH
Specific Conductance
Base Exchange Capacity
M.E. of KOH per 100 GMS. CLAY

Fig. 11. Viscosity data for 3 percent by weight bentonite suspension



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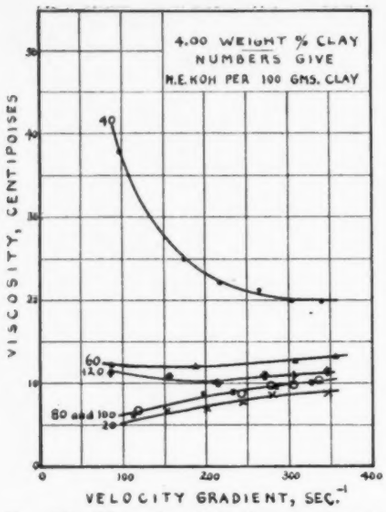
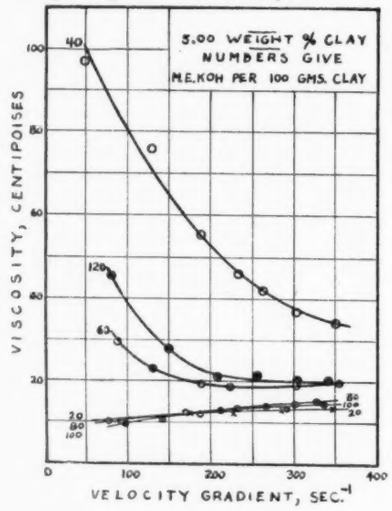


Fig. 12. Viscosity data for 4 percent by weight bentonite suspension

may be attributed to the very low value of the water dissociation constant. Second, the charge is further acting, even though weaker; for the clay particles repel each other in the 3 percent suspension at 0 m.e. KOH but not at 40 m.e. KOH. This may be attributed to the greater mobility of the hydrogen ions as compared to the potassium ion.

At the 60, 80, and 100 m.e. KOH per 100 grams clay points, the dissociation of the potassium ions from the clay crystals is largely repressed by the higher concentrations of potassium ions occurring in the water phase of the suspension. This is also indicated by the pH curve. It is generally a region of low particle charges, wherein the particles generally attract each other in

Fig .13. Viscosity data for 5 percent by weight bentonite suspension



the 3, 4, and 5 percent clay suspensions. Low viscosities are the rule.

As we have been speaking of the distances separating clay crystals in uniformly dispersed systems of 3, 4, and 5 percent suspensions, it will be of interest to tabulate the numerical values of these distances. The data of Ford, Loomis, and Fidiam[2] were used, and they had determined that they worked with a bentonite having an average equivalent diameter of 180 °A. These experimenters also calculated that the maximum ratio of breadth to thickness for disks of this equivalent size would be 58 to 1. Using these data, and assuming cubical packing, the measured specific gravity of the bentonite of 2.71, and that the volume of a disk would equal the volume of a sphere, the distance between clay particles was computed for both spheres and disks. The distances are given in Angstrom units (°A); and one °A $= 1 \times 10^{-8}$ centimeters, or about four one-billionths of an in.

Weight, percent clay	*Distance between particles (spheres) Angstrom units*	*(disks) Angstrom units*
3	468	720
4	407	583
5	366	465

The sudden increase in viscosity of the 5 percent clay suspension at the 120 m.e. KOH per 100 grams clay point brings in a new phase of colloid viscosity. This increase in viscosity is not caused by particle charges; rather, it is caused by the ions in the liquid between the particles. According to the theory of Debye and Huckel[3], electrostatic forces between ions in a solution tend to give the ions a definite arrangement, as in a salt crystal. (Thermal vibrations tend to destroy this arrangement.) The force that causes the potassium ion to dissociate from the clay must also be considered. If, then, a force exists that tends to cause a potassium ion to dissociate from a clay particle, and this is resisted by the concentration of potassium ions surrounding the particle and is transmitted out into the liquid phase by a sufficiently high concentration of potassium ions, then this force will be transmitted from one clay particle to another. Therefore, clay particles repel each other in a sufficiently high concentration of electrolyte without any net charges existing on the particles.

With regard to the 3 percent clay suspension, it must be presumed that the wider spacing occurring between clay particles would require a somewhat higher electrolyte concentration

[2]"Colloidal Chemistry of Clay Drilling Fluids," Ford, Loomis and Fidiam, *A.I.M.E. Petroleum Technology*, May, 1940, p. 11.

[3]Physik Z. 24, Debye and Huckel, 305 (1923) 26, 93 (1935).

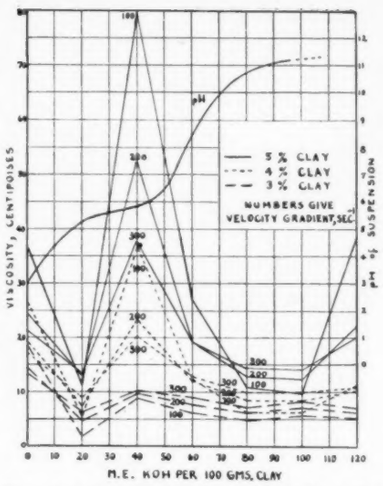
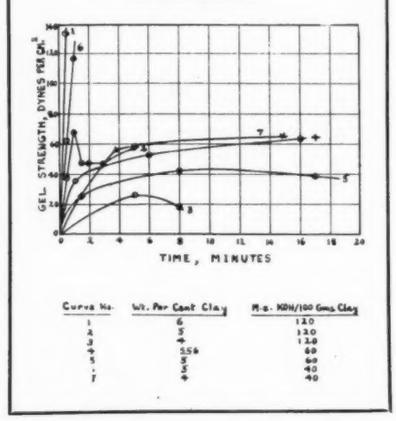


Fig. 14. Viscosity plotted against the milliequivalents of potassium hydroxide added per 100 grams of dry clay

for an effective transmittal of repulsive force from one clay particle to another than is the case in the 5 percent clay suspension. Eyring[4] has described the molecules of a liquid as arranged in a space pattern, with some of the points in the space lattice not filled by a molecule but existing as holes. Under a velocity gradient, these holes are filled by one molecule and reappear in another place and in effect dart around throughout the system and impart a degree of mobility. If the potassium ions in the clay suspension can be pictured as acting in the same fashion, we can say that, at an electrolyte concentration of 120 m.e. KOH per 100 grams clay, enough holes exist in the potassium ion space lattice between clay particles in a 3 percent suspension so that no repulsive forces are trans-

[4]"Viscosity and Diffusion as Examples of Absolute Reaction Rates", Henry Eyring, *Journal of Chemical Physics*, Volume 4, p. 283 (April, 1936).

Fig. 15. Gel rate curves for some of the mud samples to which KOH had been added


GEL STRENGTH, DYNES PER SQ. CM.
TIME, MINUTES
Curve No. | Wt. Per Cent Clay | M.e. KOH/100 Gms. Clay
1 | 6 | 120
2 | 5 | 120
3 | 4 | 120
4 | 5.56 | 60
5 | 5 | 60
6 | 5 | 40
7 | 4 | 40

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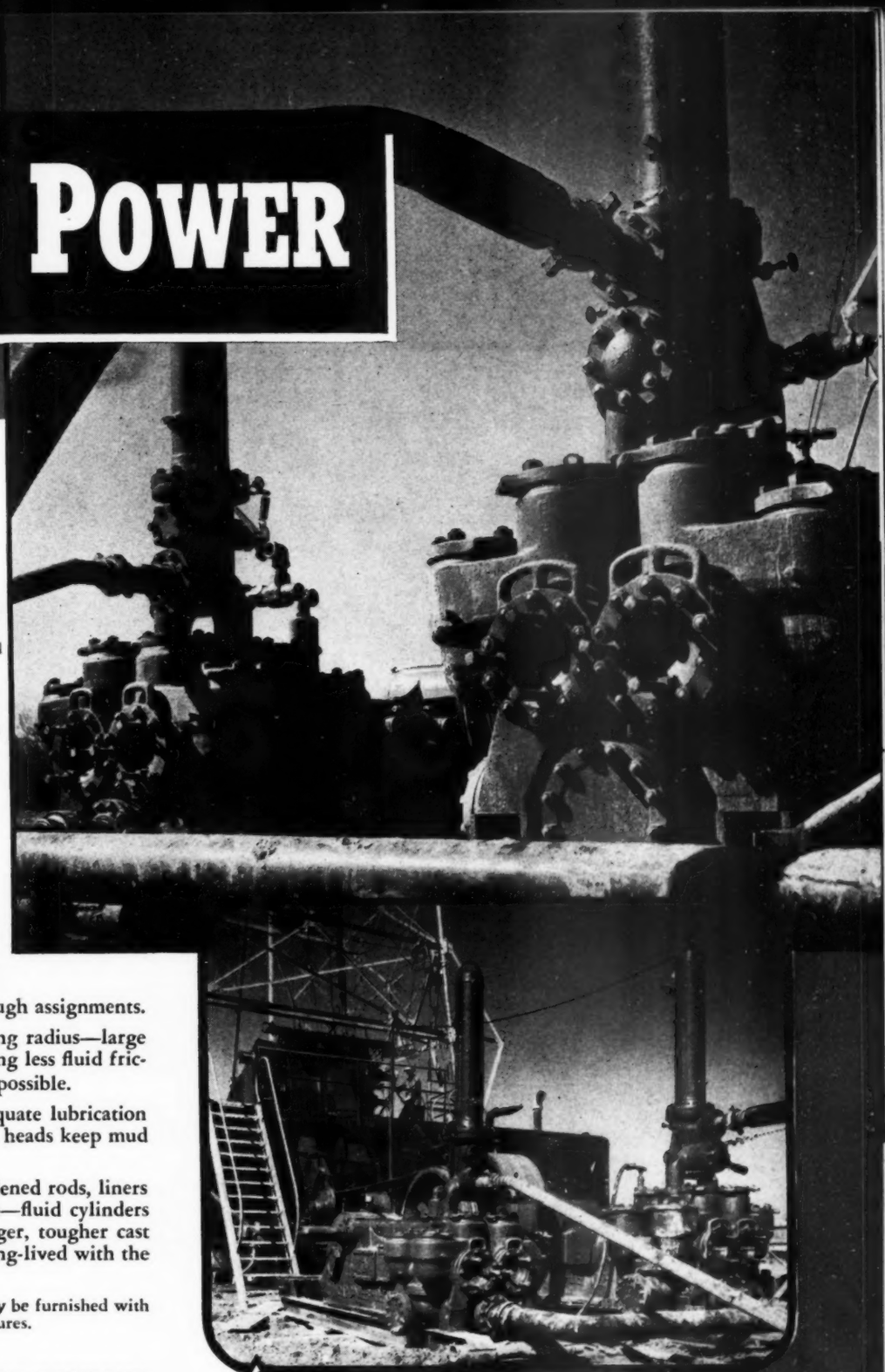

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mitted between the particles during flow.

The case of the clay, particularly the 5 percent suspension, at 120 m.e. KOH per 100 grams clay, illustrate what is commonly termed burnt-up mud. The further addition of chemicals for the purpose of reducing viscosity is useless. There is already too much present.

The gel characteristics of the samples of mud used were noted. None of the hydrogen clay samples gelled. The gel rate curves for some of the samples to which KOH had been added are given on Fig. 15. Gel strength was measured right in the viscometer by turning the pointer needle at the top of the torsion wire until the outer viscometer cup would just start to rotate. Thus, measurements of gel strength could be taken about five seconds after rotation of the inner viscometer cup had ceased. No initial measurable gel strength was found to exist (at the time when the rotation of the cup was first stopped) in any sample, although the gel rate in some was extremely rapid. In Fig. 16 the field in which gelling occurs is given as the shaded area. It can be seen that this is dependent upon both the amount of clay and the amount of electrolyte in the suspension. Superimposed upon this graph are the 10, 15, and 20 centipoise viscosity contours. The relationship between viscosity and gelling in the potassium clays can be seen; but this relationship breaks down in the region of

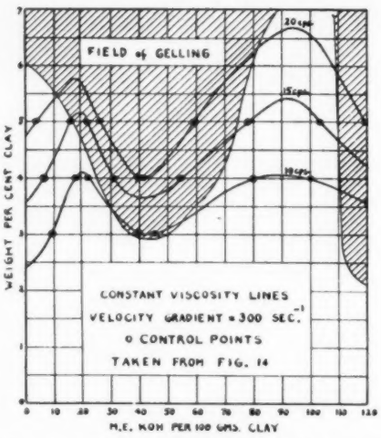


Fig. 16. Showing relationship between viscosity and gelling in the potassium clays

the hydrogen clay. This would, however, indicate that the same forces control both gelling and viscosity. Certain maximum attraction-repulsion forces are required for gelling; and these are determined to some extent by the energy of the thermal vibrations of the water molecules. These maximums are not required in order that the nature of the viscosity be determined. The mechanisms of gelling are static; the mechanisms of viscosity are dynamic.

Conclusions

1. The shape of the viscosity versus r.p.m. curve is an indication of (a) whether the colloidal clay particles attract or repel each other when uniformly dispersed within the suspension, and (b) the strength of the attraction or repulsion forces.

2. The amount of dilution required to make the viscosity of a chemically treated clay independent of the rate of flow is a measure of the effective range of the particle charge, or the mobility of the chemical ions within the suspension.

3. The ability of a colloidal clay suspension to gel is dependent upon both the amount of chemical added to the suspension and the concentration of colloid within the suspension.

4. Viscosity characteristics are not an indication of the ability of a clay suspension to form a gel; but higher viscosities may be expected in suspensions that gel because of the greater charges associated with the solid particles.

Acknowledgments

The author wishes to thank the Graduate School of The Pennsylvania State College for permission to publish this article. Sincere thanks are extended to Dr. S. J. Pirson, head of the Department of Petroleum and Natural Gas Engineering, supervisor, to Dr. F. C. Todd, Dr. E. C. Henry, Dr. S. T. Yuster, and other members of the staff who have aided the completion of this work.

☆ ☆ ☆

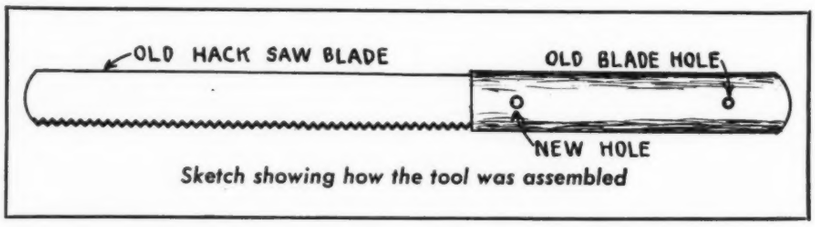
"Knife" Made From Old Hacksaw Blade

P 094.

by W. F. Schaphorst

THIS sketch shows how to make good use of old hacksaw blades. Providing one end with a wooden handle, as indicated, supplies a knife for a wide variety of cutting jobs that are otherwise handled with difficulty. For instance the knife may be used for cutting piston rod packings, for cutting through metal that is not easily accessible with an ordinary hacksaw, etc.

The hole in the end of the hacksaw blade can be utilized for fastening the handle with a rivet as indicated. A new hole may be made by heating the blade red hot and punching, for the second rivet. Or, make the handle large enough to entirely envelop the blade and insert two rivets, one above and one below the blade. The writer prefers the smaller handle, however, as indicated in the sketch.



Sketch showing how the tool was assembled

To be sure, a new blade may be used as well as an old one where greater sharpness is wanted, but for most of the ordinary cutting jobs an old blade is satisfactory.

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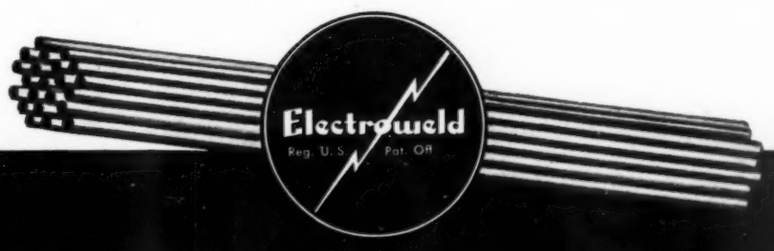

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Significance of Ignition Temperature Test of Fuels

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by A. W. Trusty,
Chief Chemist, Arkansas Fuel Oil Company

THE ignition of an explosive gaseous mixture may be brought about by means of an electric spark, a flame, or contact with a hot element. Or, as in the case of a Diesel engine, ignition may occur spontaneously if the temperature of the mixture is raised sufficiently by adiabatic compression. The ability of fuels to ignite under these conditions varies considerably with the conditions and with the chemical nature of the mixture. The "ignition temperature" may be used to predict the probable behavior of a fuel under commercial operating uses such as in a Diesel engine, an Otto engine, or to predict the relative fire hazard dangers of various substances. To illustrate a practical application of the spontaneous ignition temperature test, it was found that additions of certain dopes such as ethyl nitrate to a Diesel fuel lowered the ignition temperature of the fuel. Engine operation on the same fuel blend confirmed the prediction that the Diesel knock was reduced by the addition of such chemicals. (See Fig. 2.)

The coal mining and flour milling industries have an explosion hazard problem in the handling of dusts. The ignition of vapor-air mixtures in tanks during welding, or by frictional sparks has led to disastrous fires and explosions in the petroleum industry. A better understanding of the factors controlling ignition is desirable.

Ignition Temperature

The common conception of combustion is a rapid oxidation of a material with the appearance of a flame or an explosion. Chemical change may take place, however, at a much lower temperature than is required to develop a flame. In a broad sense the rusting of iron, or the combination of the iron metal with oxygen from the air, is an example of slow combustion. In such a case the rate of combustion is very slow. The oxidation of inflammable substances by air or oxygen proceeds at comparatively low temperatures, but

A. W. TRUSTY

graduated from Mississippi College in 1925 with a bachelor's degree—Joined staff of Lion Oil Refining Company as chemist and that same year (1925) transferred his affiliation to the Louisiana Oil Refining Company—In 1928 he became chief chemist of that company, which position he retained when later it became the Arkansas Fuel Oil Company—Resides in Shreveport, Louisiana.

owing to the dissipation to the surroundings of any heat generated, the rate of reaction does not materially increase as the oxidation continues. If, however, the heat evolved does not dissipate rapidly enough, or if an outside source of heat is supplied, the temperature of the substance will rise to the point at which a flame appears.

Ignition temperature then may be defined as that temperature to which a combustible mixture must be raised so that the heat lost from the system by conduction through the walls of the enclosure is more than counterbalanced by the rate at which it is evolved by the interaction; the reaction thus becomes self-accelerating, the temperature rising until ignition occurs and a flame appears. The ignition temperature does not necessarily correspond with an instantaneous appearance of flame; in every case there is a pre-flame period or lag during which combustion is self-propellant. The duration of such lags may vary between a small fraction of a second and 2 hours or more depending on the conditions.

Fig. 1 shows the effect of temperature on the lag. At atmospheric pressure with an ethane-air mixture at 1112°F. ignition will occur in 10 seconds time. At a temperature of 1202° F. ignition will occur in 0.6 seconds.

Various methods for determining the ignition temperature have been proposed. It is obvious that the ignition temperature cannot be regarded as a physical constant but depends on the conditions of the test. Also it is not correct to speak of the ignition temperatures of a combustible material but rather of that of a particular mixture of the material in air. The American Society for Testing Materials has standardized a procedure for the determination of the spontaneous ignition temperature. A. S. T. M. Method D 286-30 is essentially as follows:

Apparatus: Solder bath, 5 in. in diameter and 5 in. in height, filled with alloy to within about 1½ in. of the top before the flask is immersed. Glass flask, 160 ml. capacity, flat bottom, 4½ in. in height, 2⅜ in. diameter at bottom and 1⅛ in. diameter at top. Shield, gas burner, pipette and thermocouple or thermometer.

Procedure: The alloy in the solder bath shall be melted and the flask partially submerged in the molten alloy so that the bottom of the flask is approximately ¾ in. from the bottom of the iron pot. With the draft shield in position, the temperature of the bath shall be brought to and held at a temperature near the probable ignition temperature of the sample under test.

Various amounts of the sample shall be admitted to the flask from the pipette until an amount of sample is determined that will produce ignition. In successive tests at least 2 minutes shall be allowed to elapse after each addition of a sample, and the gases and vapors completely displaced in the interval be-

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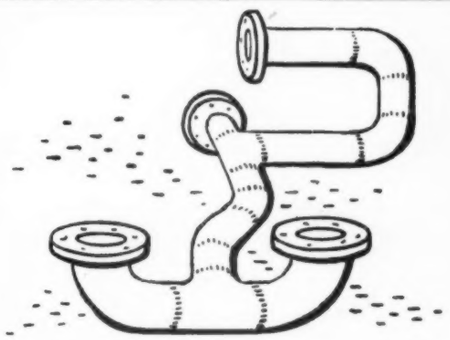

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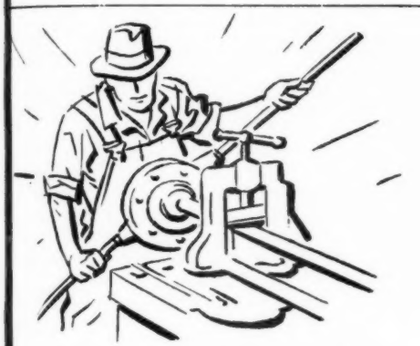

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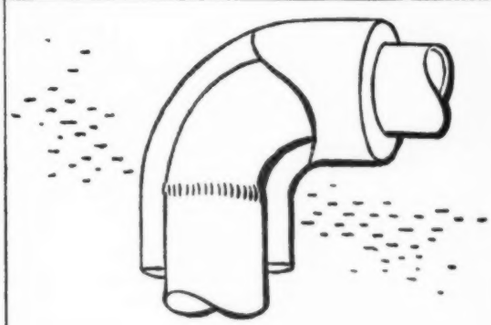

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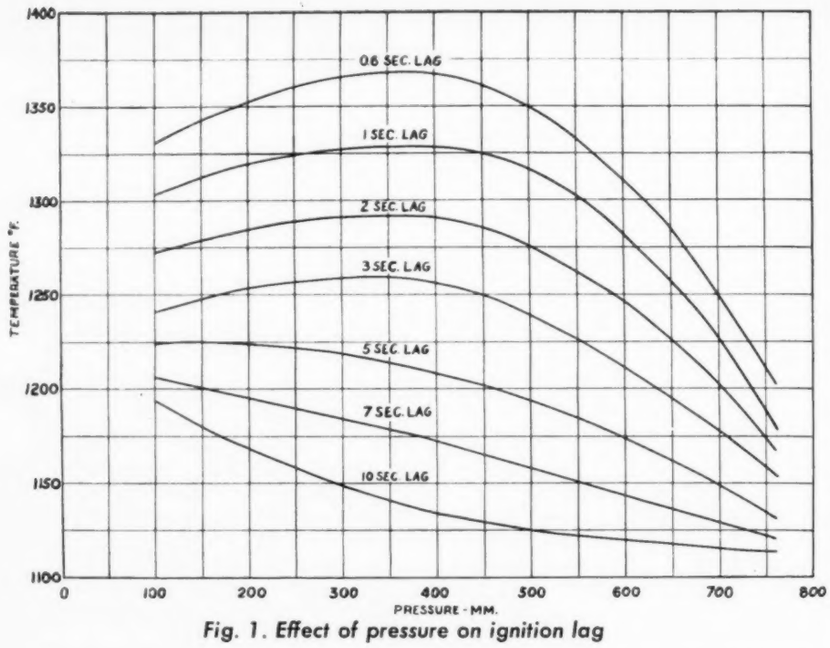


Fig. 1. Effect of pressure on ignition lag

TABLE I
Effect of oxygen on the ignition temperature

	In air °F.	*In oxygen °F.*
Hydrocarbons		
n-pentane	1074	558
n-hexane	968	547
n-octane	856	
Iso-octane	1042	
Benzene	1213	1182
Toluene	1171	1080
Miscellaneous		
Methyl alcohol	1065	910
Ethyl alcohol	1035	624
Cyclohexanol		612
Acetaldehyde	743	376
Chloroform above	1832	

tween tests by the aid of a slow stream of clean air. If ignition takes place when one of the charges is added, the temperature shall be lowered about 9°F. and the process repeated, beginning with a number of drops that ignited in the first instance. A larger and smaller number of drops should also be tried in order to be sure that the volume of test sample giving the lowest temperature of ignition shall be included in the tests.

The operation shall proceed, in general, in this manner, raising as ignition does not or does take place, holding each temperature approximately constant during all trials at that temperature, until an indicated temperature is found at which ignition takes place, but at 9°F. below which ignition fails to take place. The minimum indicated ignition temperature may then be determined by repeated trials between the indicated temperature and a temperature 9°F. less.

Considerable variation may be found in the experimental values found in the literature. This variation is caused by the variety of apparatus and methods of conducting the test. Some of the variables are as follows:

1. Material of the igniting vessel.
2. Concentration of oxygen in the inflammable mixture.
3. Volume of the ignition chamber.
4. Time lag before ignition.
5. Pressure.

Some investigators found differences in ignition temperatures with differences in the material of the igniting vessel. Others found no differences. No definite conclusion can be drawn because of the variation in other conditions during the test.

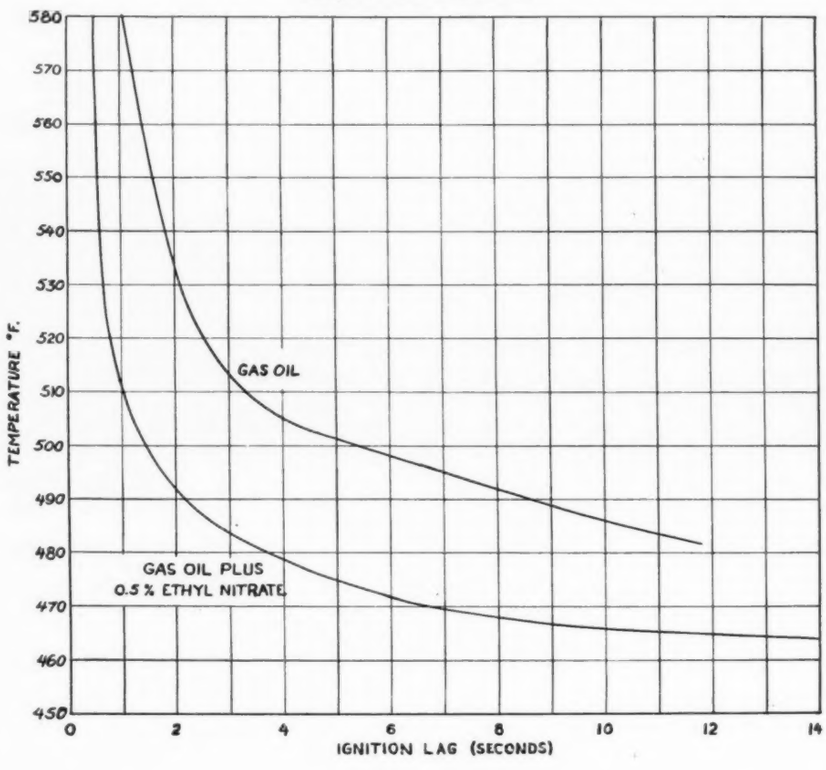
Ignition temperatures in air are generally much higher than in oxygen. A substance that will ignite feebly in air will often give a violent explosion in oxygen. (See Table 1.)

In all crucible methods of determining the ignition temperature the volume of the ignition chamber is such that the explosive mixture contains far less oxygen than that theoretically required for complete combustion. Variations in volumes of the ignition vessel, then, cause the same variation in results as are caused by a change in air-fuel ratio.

Time Lag

One of the most important variables is time lag, since during this time interval thermal decomposition, synthesis of new compounds, and oxidation of the original fuel and the resultant products may occur. It is not uncommon to find two substances of which "a" has a

Fig. 2. Addition of ethyl nitrate to Diesel fuel lowers ignition temperature of the fuel



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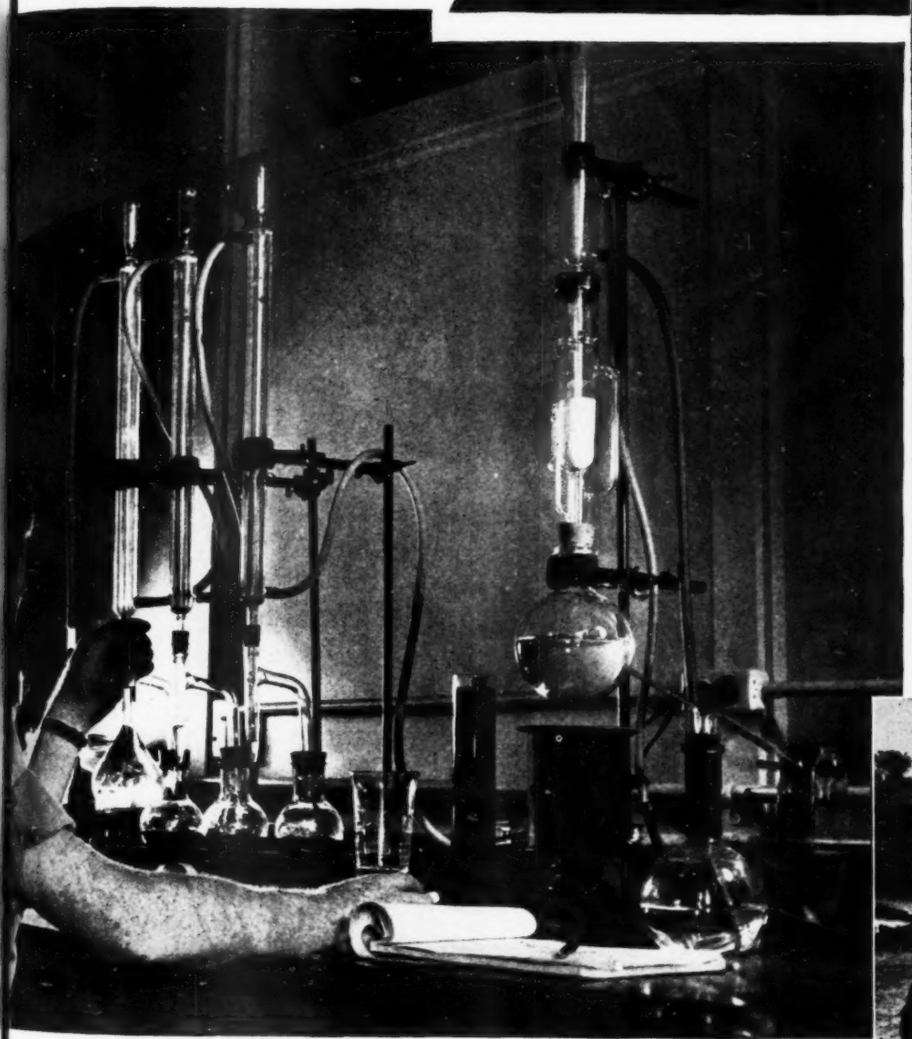

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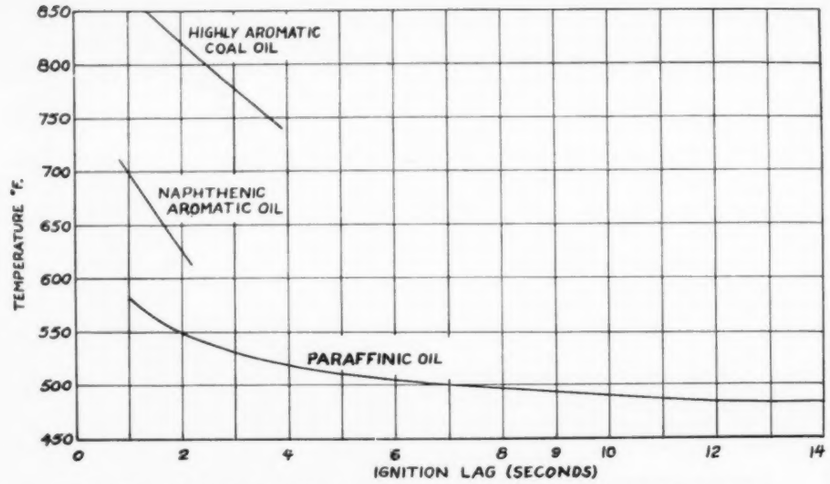

Fig. 3. Chart showing ignition temperature and lag of three different oils

lower ignition temperature than "b" at one time lag, and a higher ignition temperature than "b" at another time lag. Fig. 1 shows the effect of time lag on the ignition temperature.

Pressure

In general an increase in pressure lowers the ignition temperature. The effect of pressure is not a progressive function, however, and with most substances a sudden drop in ignition temperature is obtained when a definite critical value in pressure has been reached. Fig. 1 shows the general effect of pressure on the ignition temperature of an ethane-air mixture.

Effect of Chemical Nature

There is no relation between the flash point or burning point of a fuel and its ability to ignite spontaneously inside an engine cylinder. The following conclusions may be drawn concerning the effect of chemical composition:

1. Simple molecules have higher spontaneous ignition temperatures than similar compounds containing more complex molecules.

2. The open-chain paraffin hydrocarbons have low ignition temperatures, the temperature decreasing with rise in molecular weight of the hydrocarbons.

3. The branched chain paraffins, especially those of short open-chain length, have much higher ignition temperatures than the corresponding normal paraffins.

4. The olefines have variable ignition temperatures, but are often higher than those of the corresponding paraffins.

5. Naphthenes, in general, have higher ignition temperatures than those of n-paraffins and olefines containing the same number of carbon atoms.

6. The aromatic hydrocarbons have much higher ignition temperatures than other hydrocarbons, with the exception of branched-chain paraffin hydrocarbons such as 2,2,4-trimethylpentane.

7. Alcohols possess higher ignition temperatures than the corresponding hydrocarbons.

8. Aldehydes have much lower ignition temperatures than the corresponding hydrocarbons.

9. The introduction of bromine or chlorine atoms or nitro groups into the molecules of hydrocarbons leads, in general, to a reduction in ignition temperature; but on the other hand, the introduction of amino groups causes a marked increase in ignition temperature. (See Table 2.)

TABLE 2

Effect of additions to fuels on ignition temperature. Ethyl nitrate decreases ignition temperature

	Ignition temperature °F. (with 1 sec. time lag)
Diesel fuel	572
Same plus 0.5% ethyl nitrate	509
Same plus 1.0% ethyl nitrate	491
Same plus 2.0% ethyl nitrate	473
Tetra-ethyl lead increases the ignition temperature of a gasoline:[2]	
	Ignition temperature °F.
Gasoline	635
Gasoline plus 0.5% tetra-ethyl lead	824
Gasoline plus 1.0% tetra-ethyl lead	869
Gasoline plus 2.9% iron carbonyl	941
Gasoline plus 1.0% selenium diethyl	887

References

1. *The Science of Petroleum.* Page 2959.
2. Weerman, *Journal of the Institute of Petroleum Technology,* 13, 300 (1927).

☆ ☆ ☆

P 967.6

California Plant to Produce Butadiene

IN ORDER that synthetic rubber production may begin on the Pacific Coast at the earliest possible date, a sizeable construction program now is under way at one of the Southern California Gas Company's manufactured gas plants.

Under this program the gas company has awarded contract for an extraction plant to be constructed by C. F. Braun Company for the purpose of taking high-pressure gas from the outlet of the company's compressor plant and extracting the crude butadiene. Additions to existing boiler plant and gas generating facilities are being constructed by the gas company under an agreement with the Defense Plant Corporation.

As a very considerable amount of existing gas plant equipment required in the butadiene process is available at the Southern California Gas Company's works, a considerable saving in expenditures for large amounts of critical materials has been effected.

An operating agreement has been made by the Rubber Reserve Company and the gas company, whereby Rubber Reserve will supply gasoline feed stock, which will be used for producing gas containing butadiene. Rubber Reserve will pay its standard fee per ton of butadiene produced, which fee also covers the management expense of plant operations, as well as any charges that may be assigned for the use of the gas company's equipment, valued at approximately $6,750,000.

Estimated production of butadiene by the gas company is 30,000 tons per year. Crude butadiene will be transported by pipe line from the gas plant to Shell Chemical Company near Torrance for purification, and then delivered to a co-polymer plant, where it will be polymerized with styrene to produce synthetic rubber.

Initial steps looking toward the development of this project were taken in April of this year when technical engineers representing Rubber Reserve Company made a nation-wide survey of existing plants potentially suitable for the production of butadiene.

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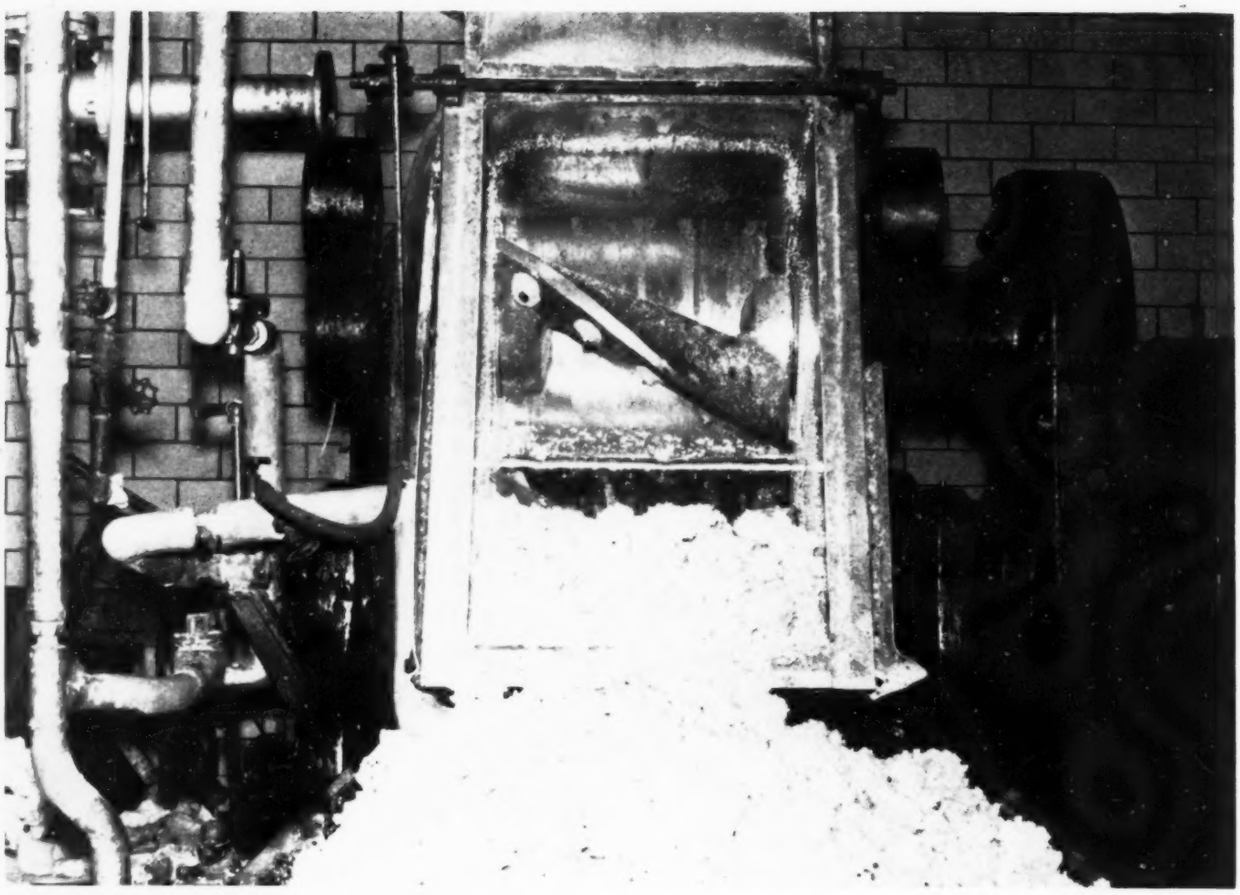

Crude Vistanex after washing

Vistanex—An *Iso*butene Polymer

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☆ **Viscosity index of lubricating oils improved by addition of small percentage of Vistanex of low molecular weight**

by C. C. Pryor
Associate Editor

VISTANEX, a rubber-like product lacking the virtue of being vulcanizeable, was developed first in Germany where it was known as Opannoll. In the United States it was developed by the Standard Oil Company of New Jersey. Vistanex is a polymer of *iso*butene, a petroleum hydrocarbon, and is substantially lacking in unsaturation, which accounts for many of its properties. Polymerization of *iso*butene is conducted at low temperatures with catalysts such as boron fluoride or aluminum chloride being employed. This reaction is extremely rapid and is often completed in a fraction of a second. The temperature at which the reaction occurs controls the molecular weight of the product.

This rubber-like product has a wide variety of uses. It is currently being successfully employed in the manufacture of gaskets, packings and caulking compounds, which remain permanently flexible and do not oxidize. In these cases it is mixed with a variety of fillers. When Vistanex is mixed with other compounds, such as asphalts and resins, it imparts low temperature flexibility, added resistance to moisture and adhesion to metals. Adhesives, too, may be manufactured by dissolving Vistanex in aliphatic hydrocarbons, adding resins or low molecular weight Vistanex to impart thickness. As a plasticizer this relatively new product is useful for compounding with waxes and many resins, especially those of a predominantly hydrocarbon character. During the present war emergency, all supplies of Vistanex are under allocation and control for use in war industries.

Vistanex has many desirable physical properties, outstanding of which may well be its excellent electrical properties, which make it a most desirable agent for improving the properties of a great number of products made from natural rubber. It undergoes cold flow and therefore, when used by itself, shows very little or no structural

strength. This, however, is overcome by compounding with fillers and vulcanizeable rubbers. When more than 50 percent of Vistanex is mixed with natural rubber, the chemical characteristics of the Vistanex are predominant over those of rubber.

The tensile strength of this product ranges up to about 1500 lb. per sq. in., maximum, and its density is about 0.91. The tensile strength of Vistanex polymers increases rapidly above a molecular weight of 60,000. Another of its features is its high resistance to strong chemicals and ozone.

Vistanex is soluble in hydrocarbon solvents but is insoluble in alcohols, esters, ketones and the like. It is superior to natural rubber in respect to impermeability to gases and absorption of moisture. By a continued mechanical working or heating, Vistanex can be broken down to products of lower molecular weight. It undergoes chlorination, yielding a dry, colorless, resinous product. Vistanex does not bounce at ordinary temperatures, but balls of it heated to 100°C. have rebound close to that of rubber.

Vistanex is employed to improve rubber compounds, petroleum products, hot melt coatings, adhesives and impart desirable properties to a vast variety of commodities, such as caulking compounds, resins, gaskets, packings and asphalts, and electrical insulations.

Low molecular weight grades of Vistanex used in small percentages improve the viscosity index of lubricating oils; that is, the temperature viscosity relations of Mid-Continent or Coastal oils can be made to approach and surpass those of Pennsylvania oils. With the use of such compositions, it is possible to devise lubricating oils that do not thicken considerably at low temperatures. These Vistanex grades are also useful for compounding with paraffin wax to produce hot melt adhesives and paper coatings that are flexible at low temperatures and more impervious to moisture than are ordinary wax coatings. This latter is largely due to the fact that the presence of Vistanex inhibits the formation of wax crystals. Plastic paraffin waxes useful for a variety of articles are also made by such compounding.

Medium and high molecular weight grades are mixed with rubber to improve its quality, the softer types used alone being desirable for self-sealing linings of aircraft gasoline tanks.

Ozone does not cause cracking of Vistanex and it has been found that compounds containing equal parts of Vistanex and rubber are attacked at a very slow rate. Such compositions are desirable for insulation of wires and cables operated under high voltages. A similar mixture is also resistant to concentrated sulphuric acid and is therefore useful as acid linings. More highly resistant linings may be produced by milling the Vistanex with proper fillers. Mixed with rubber, Vistanex imparts added resistance to deterioration from heat and oxidation and is applicable in the manufacture of steam hose, belt coverings and other places where high temperatures are met. Such compounds may be used to manufacture inner tubes, gas masks, and balloon cloths, which are less permeable to gases than natural rubber alone.

Material for this article supplied by Standard Oil Company of New Jersey.

☆ ☆ ☆

P 094.

Well-Organized Shop for Welding Oil-Field Equipment

FAST and efficient welding calls for a well-organized shop set-up and a carefully planned operation.

An excellent example of such a plant is Black, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma, manufacturers of welded tanks, separators, walkways, and welded vessels for the oil fields and refineries.

The concern, which serves the Mid-Continent area, has a fully equipped Class 1 shop that utilizes 71 welding machines supplied by The Lincoln Electric Company, Cleveland, Ohio. Forty-six of these are in the Oklahoma City shop.

Work on huge pressure tanks such as the one shown in Fig. 1 requires that the welders be comfortably positioned at all times. Here eight men work simultaneously and at a high rate of speed on outlets for the vessel. To make it possible to rotate a vessel such as this, engineers have them placed in arc-welded roller mountings, several of which may be seen near the bottom of the picture.

To comply with rigid regulations in the welding of pressure vessels and to assure production of equipment of the highest possible quality, the company uses carefully controlled procedure, and high quality equipment and workmanship. In addition, there is radiograph equipment for the inspection of welds and a large stress-relieving oven. This large structure is 78 ft., 6 in. long, 13 ft. wide, and 14 ft. high. Carefully controlled burners permit the heat to be regulated in order that the large vessels that the concern fabricates may be heated to the proper temperatures to relieve any stresses set up by the welding operations. Proper stress-relieving procedures are essential to the production of high-quality vessels.

The company's well-planned assembly bay is a room 520 ft. long, 80 ft. wide, and 30 ft. high. Proper arrangement of the work and equipment is essential in a shop of this type, where high quality welded equipment must be turned out at high speed.

Fig. 1. Welders at work on a huge pressure container for the refinery industry

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Chemical Utilization of Natural Gas, Natural Gasoline Hydrocarbons by Oxidation[1]

☆ Although the petroleum industry controls the cheapest source of hydrocarbon raw material, seemingly it has been slow to capitalize upon the fact

by Hooper Linford

Research Chemist, Union Oil Company of California

NATURAL gas and natural gasoline are composed primarily of mixtures of the simpler or lower molecular weight paraffin hydrocarbons. Although the paraffins were originally thought to be inert chemically, they are actually chemically active and are readily converted into various widely different chemical derivatives. Moreover, the huge supplies and low values of both of these commodities make them particularly suitable as basic raw materials for the manufacture of organic chemicals. Although there are several general processes being used to synthesize organic chemicals from hydrocarbons, the object of this article is to point out some of the potentialities of processes involving oxidation.

Natural Gas

Natural gas consists primarily of methane, but usually contains ethane, propane, and higher molecular weight paraffin hydrocarbons in decreasing proportions together with small percentages of nitrogen, carbon dioxide, and occasionally helium. The greater part of the natural gas produced in the United States is treated for the removal of natural gasoline and the dry gas used as a fuel for both domestic and commercial purposes, although until recently enormous quantities of natural gas have been burned or vented to the atmosphere.

According to figures presented by the Bureau of Mines[2] the estimated production of natural gas in the United States in 1939 was 3,333,500,000,000 cu. ft. Of this amount 2,476,756,000,000 cu. ft., or about 74 percent, was marketed; 856,744,000,000 cu. ft., or 26 percent, presumably being used in the oil fields for pressuring wells, etc., or wasted. Roughly, 15 percent of the marketed gas was used in the production of carbon black and 85 percent used as fuel. The average value for natural gas in the United States in 1939 was 4.9 cents per M. cu. ft.

HOOPER LINFORD

graduated from Utah Agricultural College in 1926; received an M.S. degree from the State College of Washington in 1928, and a Ph.D. degree from the University of Cincinnati in 1931—Organic chemistry was his major field of study during all graduate work as well as one year spent at the University of California as a research associate in chemistry—Has been employed as research chemist by the Union Oil Company of California for the last 10 years and during the greater part of that time has been engaged in studying the oxidation of petroleum fractions—Is a member of Alpha Chi Sigma, professional chemical fraternity, and Sigma Xi, national scientific honorary society.

Some interesting calculations have been made to show the weight of natural gas produced in the United States. By making broad assumptions regarding its average composition it is estimated that in 1939 there was produced about 100,000,000 tons of natural gas. Assuming that all of the gas was treated for the recovery of natural gasoline there should have been produced about 9,000,000 tons of natural gasoline, including butane and propane, leaving approximately 91,000,000 tons of the dry gas. This is obviously a rich raw-material source and justifies investigation of its possible chemical utilization.

Natural Gasoline

Stabilized natural gasoline is usually considered to consist of a mixture of the saturated paraffin hydrocarbons from the butanes to the octanes (C_4 to C_8) although it is usually found to contain small proportions of some of the higher molecular paraffins. The composition of natural gasoline varies with the source and it is often found to contain varying small proportions of aromatic hydrocarbons such as benzene, toluene and xylene, as well as naphthene hydrocarbons such as cyclopentane and cyclohexane and their simpler derivatives. Natural gasoline is used for blending in the preparation of motor fuels where it has particular value because of its low boiling point range and its rather high knock rating and lead susceptibility.

The total production of natural gasoline in the United States in 1941 amounted to 2,696,568,000 gal.[3] Although no information is available regarding the average value of this commodity in 1941, it is believed it is not far different from the average value for 1940, which was estimated to be approximately 3 cents per gal.[4] This gasoline had an average vapor pressure (Reid) of about 20 lb. and was, therefore, a stabilized product from which propane and some of the butanes had been removed. Assuming an average weight per gallon of 5.6 lb. for the natural gasoline the quantity produced in 1941 was about 7,550,000 tons.

Although data are not available for the 1941 production of propane and butane, which are obtained by topping the wild natural gasoline, it has been estimated, on the basis of the 1939 production data, that there should have been produced approximately 102,000,000 gal. (249,000 tons) of pro-

[1] Presented before The California Natural Gasoline Association's Annual Meeting, November 6, 1942, Los Angeles, California.

[2] P. S. Lott and G. R. Hopkins, *Minerals Yearbook, Review of 1940, U. S. Bureau of Mines*, page 1029.

[3] *Monthly Natural Gasoline Report No. NGR 944a-84*, December, 1941, U. S. Bureau of Mines.

[4] "*Natural Gasoline and Liquefied Petroleum Gases*," G. R. Hopkins and A. T. Coumbe, (preprint) from *Minerals Yearbook 1940, U. S. Bureau of Mines*, page 1065.

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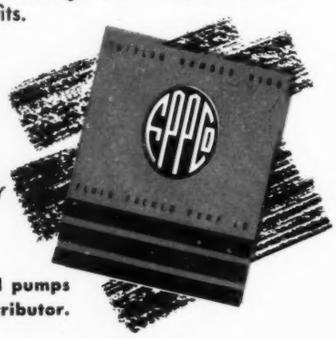

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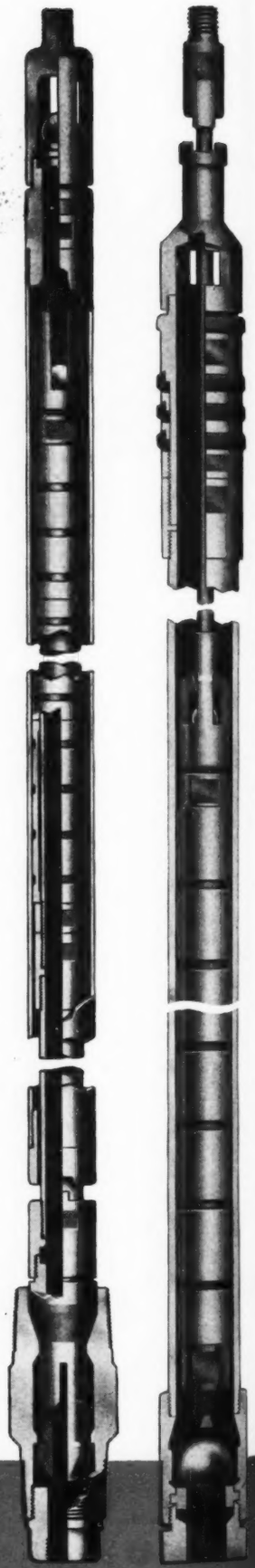

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pane, 92,000,000 gal. (230,000 tons) of butane, and 89,000,000 gal. (220,000 tons) of a mixture of propane and butane. In addition to these two hydrocarbons, small amounts of a pentane fraction are produced for use as a liquid fuel. Calculations based on the 1939 production data indicate that approximately 5,000,000 gal. (13,000 tons) of this fraction were probably produced in 1941.

The above data are presented with the object of pointing out the vastness of the supply of low molecular weight hydrocarbons available in the United States as well as the relatively low values assigned to the products that they constitute. In this latter connection it is interesting that natural gas at 4.9 cents per M. cu. ft. is worth approximately 0.1 cent per lb. and that natural gasoline at 3.0 cents per gal. is worth approximately 0.5 cent per lb.

Chemical Utilization of Paraffin Hydrocarbons

In considering the chemical utilization of paraffin hydrocarbons three general types of chemical processes appear to be applicable: namely, pyrolysis, halogenation, and oxidation. Commercial applications of each of these processes have been developed to a limited degree, but in no case have their full possibilities been exploited. Large petroleum chemical industries can, and undoubtedly will, be built around these basic processes in the not too distant future.

Pyrolysis

Processes in which high temperatures are used for the purpose of cracking or decomposing the hydrocarbons are referred to as pyrolytic processes. Pyrolysis of the lower hydrocarbons may result in the production of carbon, hydrogen, olefins (unsaturated hydrocarbons) and various liquid products. The latter type of compounds, resulting from the polymerization or condensation of fragments of molecules, often contain aromatic hydrocarbons in appreciable concentrations. The products of pyrolysis may be isolated and marketed as such or they may be used as raw materials for chemical synthesis. For example, the olefins produced in cracking operations may be converted into alcohols by reacting them with sulphuric acid and hydrolyzing the sulphate addition products to obtain the alcohols. Also, butadiene, a product of pyrolysis, is used in the manufacture of synthetic (Buna) rubbers.

Halogenation

The lower paraffin hydrocarbons may be treated directly with a halogen, preferably chlorine, to produce mono-, di-, tri-, or poly-halides. These halogen derivatives may be marketed directly or they may be used as chemical intermediates in the formation of many types of organic chemicals. As an example, carbon tetrachloride, which may be produced by the direct chlorination of methane, is used as a dry-cleaning fluid, an industrial solvent and as a fire extinguisher. This compound may be converted into the refrigerant "Freon" ($C\ Cl_2F_2$) by treatment with antimony trifluoride. The mixed amyl acetates, which have a large use as lacquer solvents, are prepared by chlorinating a mixture of pentanes, hydrolyzing the chlorides to produce the alcohols, and reacting the alcohols with acetic acid to produce the esters.

Oxidation

Under controlled conditions oxygen can be made to react with the paraffin hydrocarbons to produce a large number of oxygenated derivatives that are valuable commercial chemicals. This method of chemical utilization is of particular interest from a commercial standpoint because air can be used as the oxidizing medium. Moreover, oxidation processes can often be carried out at lower temperatures and pressures than are required in many important industrial processes.

The products of oxidation include: alcohols, aldehydes, ketones, acids and esters as well as carbon monoxide and hydrogen. Although it would be impossible to list all uses of each of these products, some of their more important uses are discussed briefly. The alcohols are valuable solvents and chemical intermediates. Formaldehyde is used in the manufacture of synthetic resins, as will be described later. Acetaldehyde, the only other aldehyde produced in quantity by the oxidation of the lower paraffins, is used in the production of synthetic resins and also in the manufacture of acetic acid. Of the ketones, acetone is believed to be the only one produced in appreciable quantities. This compound has excellent solvent properties and is used as a lacquer solvent and also in the manufacture of smokeless powder. Acetic acid is possibly the most important acid produced by the oxidation of paraffins and this compound is used in large quantities in the manufacture of acetate rayons as well as in the manufacture of acetate solvents. Most of the lower molecular weight acids produced, however, can be used in the manufacture of esters for use as solvents, or can be utilized as chemical intermediates. The esters produced directly by oxidation are valuable solvents. Carbon monoxide and hydrogen have been used in large quantities in the production of synthetic methanol.

Oxidation of Paraffin Hydrocarbons—Experimental Studies

Our interest lies primarily in the paraffin hydrocarbons, including the normal and *iso* forms, from methane to octane (C_1 to C_8) for, although other types of hydrocarbons are often present in natural gasoline, the proportion of these latter compounds is usually low. From a theoretical, if not from a practical standpoint, it is possible to isolate, by fractional distillation processes, the lower members of the paraffin series so that it has been possible to investigate the oxidation reactions of individual hydrocarbons. A rather large amount of exploratory work has been carried out by many investigators in connection with the study of the oxidation of the lower paraffins. Although some of this work has been of an academic nature, most of the more recent work has had as its object the finding of conditions that will lead to the production of maximum yields of valuable chemicals, with the view to developing commercially feasible oxidation processes.

Probably the greatest obstacle to the development of oxidation processes applied to methane, or natural gas, has been the difficulty in controlling the reaction to prevent the complete combustion of the hydrocarbons to carbon dioxide and water. It is generally found, particularly with the lower hydrocarbons such as methane and ethane, that when conditions are imposed which are capable of starting the oxidation reaction, these same conditions are sufficiently severe to carry the reaction to completion. This makes it particularly difficult to isolate the intermediate oxidation products. The difficulty encountered in stopping the oxidation reaction, or series of reactions, at some intermediate point is occasioned by the fact that, in general, the partial oxidation products are more easily oxidized than the parent hydrocarbon.

Methods that have been employed for controlling the oxidation reaction are, briefly: (1) the use of small proportions of oxygen or air, i.e., low oxygen to hydrocarbon ratios, (2) the use of short reaction times followed by immediate quenching of the reaction products, and (3) the use of catalysts to direct the oxidation or to allow the reaction to take place under less severe conditions of temperature and pressure than would be required without catalysts.

A brief summary of some of the more recent experimental work that has been carried out on the lower members of the paraffin hydrocarbon series

has been prepared in order to indicate the possibilities that are presented by the development of oxidation processes. No attempt has been made to include oxidation studies made with oxidizing agents other than oxygen or air and very little information is included regarding the use of catalysts. In this latter connection it can be stated that generally most of the reactions discussed in this summary can be carried out at lower temperatures and with somewhat better control by the use of catalysts. Oxidation catalysts that have been used in the experimental work include nitrogen oxides and metals such as calcium, chromel, silver, aluminum and nickel. An effort has been made where possible to present yield data as well as to list the oxidation products for each hydrocarbon.

Methane

Methane, the simplest hydrocarbon compound, is the main constituent of natural gas. It is the most difficult to oxidize of any of the paraffins and, in this case, the intermediate oxidation products of methane are all far more susceptible to oxidation than methane. For this reason it is particularly difficult to control the oxidation reaction in such a manner that carbon dioxide and water are not the only products.

The simple theoretical reactions that occur between methane and oxygen are illustrated in Fig. 1. It is theoretically possible to produce any one or all of the compounds shown in this figure by exercising proper control of the conditions of oxidation. Padovani and Franchetti[5] found that the reaction to form carbon monoxide and hydrogen (Reaction 5) takes place with good yields over a nickel catalyst at temperatures of 1560-2190°F., whereas Wiezevich and Frolich[6] found that methane reacted with air at 930° F. under a pressure of 135 atmospheres (about 2,000 lb. per sq. in.) to give methanol, formaldehyde and formic acid. At temperatures above about 930°F. the reaction tended to form carbon oxides. Operating at the lower temperature these investigators found that the ratio of production of methanol to formaldehyde was between three and eight parts of the former to one of the latter, indicating that the conditions employed favored reaction (1).

FIG. 1

Reactions between methane and oxygen

1.	$CH_4+0=CH_3OH$	Methanol
2.	$CH_4+2\ O=CH_2O+H_2O$	Formaldehyde
3.	$CH_4+3\ O=HCO_2H+H_2O$	Formic acid
4.	$CH_4+4\ O=CO_2+2H_2O$	Carbon dioxide
5.	$CH_4+0=CO+2H_2$	Carbon monoxide and hydrogen

The work of Wiezevich and Frolich was carried out on a sample of methane containing small percentages of ethane. It was pointed out by these authors that in experiments conducted with a sample of methane containing only 0.36 percent of ethane slightly higher temperatures were required (970°F. or higher) to effect oxidation and most of the oxidation products were carbon oxides and water. However, small amounts of methanol, formaldehyde and formic acid were obtained.

Burke and Fryling[7] oxidized methane with 50 percent by volume of air at temperatures of 390° to 930°F. and pressures of 200-1750 lb. per sq. in. without the use of catalysts and they obtained primarily aldehydes and acids. On the other hand Paris[8] found that by oxidizing methane using low oxygen to hydrocarbon ratios under high pressures the reaction leading to the formation of methanol was predominant. Although temperature did not appear to be as important as pressure in directing the reaction it was found that maximum yields of methanol were obtained at about 840°F.

It is believed that most of the experimental work carried out with methane has been done with an impure methane containing small percentages of ethane and possibly even propane and for this reason too much importance should not be placed on much of the data obtained. Partial oxidation of pure methane would undoubtedly be more difficult to control than the oxidation of methane containing even small percentages of ethane, and it is believed that further study should be given to reactions of the pure compound.

Ethane

The second member of the paraffin series of hydrocarbons, ethane, is appreciably more easily oxidized than methane, but still less readily attacked by oxygen than the higher members of the series. Ethane is found in natural gas in amounts varying from 0 to 25 percent or even higher depending on the source of the gas.

Theoretically the oxidation of ethane should result in the production of alcohols, aldehydes, and acids corresponding to ethane and, because of the tendency for the carbon-to-carbon bond to rupture under the conditions employed for oxidation, particularly in the presence of oxygen, the same series of compounds corresponding to methane should also be expected in the reaction products. In this connection it has been found that the greater part of the partial oxidation products of ethane are ethane derivatives, i.e., they contain two carbon atoms, but appreciable quantities of oxygenated derivatives of methane are also obtained.

Newitt and Townsend[9] found that ethane could be oxidized at 520°F. under 100 atmospheres pressure with the production of rather large proportions of ethanol and methanol and smaller proportions of the corresponding aldehydes and acids. Although data regarding the percentage of ethane oxidized per pass through the reaction zone are not available, recalculation of the yield data presented by these investigators indicates that by completely oxidizing 1000 cu. ft. of ethane gas (about 84.6 lb.) they would be able to produce 103 lb. of liquid products. Data regarding the yields of the various oxidation products of ethane are shown in Table 1.

TABLE I

Products of the partial oxidation of ethane

(Pressure, 100 atmospheres; temperature, 520°F.)

Product	Production per M. cu. ft.* (84.6 lb.) ethane consumed	
	Weight, lb.	Volume, gal.
Ethanol	52.5	8.0
Methanol	28.9	4.3
Acetaldehyde	11.4	1.7
Acetic acid	9.3	1.1
Formaldehyde	0.3	0.04
Formic acid	0.6	0.06
Total useful products	103.0	15.20

*Measured at 32°F. and 29.9 in. of mercury pressure.

Propane

Propane, the third member of the paraffin series, is obtained by topping or stabilizing natural gasoline. This compound, which is more easily oxidized than either ethane or methane, also gives rise to a greater number of oxidation products. Thus, it is theoretically possible to produce alcohols, aldehydes and acids containing one, two and three-carbon atoms, the one and two-carbon atom derivatives resulting from the fission of the carbon-to-carbon bond. Also, a new type of compound is formed in propane oxidation, namely, acetone, the simplest ketone.

Wiezevich and Frolich[6] reported that by oxidizing 98 percent propane with pure oxygen at 170 atmospheres pressure and 660°F., without the use of a catalyst, they were able to convert approximately 5.2 percent of the feed per pass into oxygenated derivatives. Data presented by these investigators have been recalculated to show the yields of the various products per M. cu. ft.

[5]C. Pandovani and P. Franchetti, *Giorn. chem. ind. applicata, 15*, 429 (1933); *Chemical Abstracts, 28*, 2853 (1934).

[6]P. J. Wiezevich and P. K. Frolich, *Industrial Engineering Chemistry, 26*, 267 (1934).

[7]S. P. Burke, and C. F. Fryling, U. S. Patent 1,991,344, Feb. 12, 1935; *Chemical Abstract, 29*, 2174 (1935).

[8]A. Paris, *Chimie et industrie, 31*, Spec. No., 411 (1934); *Chemical Abstract 28*, 5806 (1934).

[9]D. M. Newitt and D. T. A. Townsend, *Journal of the Institute Petroleum Technology, 20*, 252A (1934); *Chemical Abstract, 28*, 4871 (1934).

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(about 126 lb.) of propane oxidized. These data are shown in Table 2.

TABLE 2
Products of the partial oxidation of propane
(Pressure, 170 atmospheres; temperature, 660°F.; conversion per pass, 5.2 percent)

Product	Production per M. cu. ft.* (126 lb.) propane consumed	
	Weight, lb.	Volume, gal.
Formaldehyde	1.3	0.2
Acetaldehyde	36.7	5.6
Acetone	12.5	1.9
Methanol	40.1	6.0
Ethanol	34.4	5.2
Propanol	29.1	4.3
Butanol	4.8	0.7
Acetic acid (containing formic acid)	11.5	1.3
Total useful products	170.4	25.2
Carbon dioxide	20.7	....
Carbon monoxide	25.4	....
Water	51.6	6.2

*Measured at 32°F. and 29.9 in. of mercury pressure.

These investigators found that the yields of acids could be increased, at the expense of the alcohols and aldehydes, by extracting the acids from the oxidation products and recycling the intermediate oxidation products along with the propane and fresh quantities of oxygen. As might be expected the proportion of propane being oxidized to carbon dioxide and water also increased in this method of operation.

Butane

Oxidation of the butanes (normal and *iso*-), which are present in rather large proportions in natural gasoline, results in the production of a considerable number of oxygenated derivatives. Wiezevich and Frolich[6] report that a sample of 95 percent butane oxidized readily at temperatures of 410-490°F. and pressures of 33-160 atmospheres. They were able to identify alcohols containing one, two, three and four-carbon atoms, acetaldehyde, propionaldehyde, acetone, acetic acid, and propyl acetate. The latter compound is an ester resulting from the reaction between acetic acid and propanol. These investigators found that in general the lower pressures favored the formation of low molecular weight alcohols and acids, whereas the higher pressures favored the formation of higher molecular weight alcohols and aldehydes.

Bludworth[10] believes that the oxidation of butane can be controlled by a method involving many recyclings of reactants using only very small amounts of oxygen. He indicates that he is able to produce eight gallons of liquid oxidation products from 1000 cu. ft. of butane gas by recycling 15 or 16 times. The product was found to consist of approximately 75 percent methanol, 12.5 percent acetone and 12.5 percent acetaldehyde.

[10] J. E. Bludworth, U. S. Patent 1,923,610, Aug. 22, 1933; *Chemical Abstract*, 27, 5341 (1933).

Pentane

The products of the partial oxidation of pentanes are complex mixtures and are not readily separated into individual components. Thus, Wiezevich and Frolich[6] oxidized a mixture of pentanes consisting of 60 percent normal and 40 percent *iso*pentane at 465°F. and 200 atmospheres pressure and obtained a series of alcohols ranging from methanol to the pentanols (containing five carbon atoms) together with acetaldehyde, acetone, and formic and acetic acids. It is interesting that the products were mainly in the two and three-carbon atom range indicating that the pentane molecule was broken between the second and third-carbon atoms.

In a small plant operating with a flow rate of 2.0 gal. per minute it was found that the total liquid oxidation products amounted to 87.5 gal. per day. This plant was operated with recycling of the pentane and a pentane balance indicated that 1.7 gal. of pentane were consumed for each gallon of liquid products. Calculations have been made to show the yields of the various oxidation products for each 100 lb. (19.2 gal.) of pentane consumed and these data are presented in Table 3.

TABLE 3
Products of the partial oxidation of pentane
(Pressure, 200 atmospheres; temperature, 465°F.)

Product	Production per 100 lb. (19.2 gal.) pentane consumed	
	Weight, lb.	Volume, gal.
Acetaldehyde	5.3	0.8
Methyl acetone*	12.2	1.8
Alcohols (boiling up to 230°F.)†	†26.8	4.0
Alcohols (boiling 230-266°F.)‡	8.7	1.3
Acetic acid	27.0	3.1
Formic acid	2.8	0.3
Total useful products	82.8	11.3

*Mixture of methanol and acetone containing about 15 percent of the former.
†Believed to contain ethanol, n- and isopropanols, and small amounts of tert-pentanol.
‡Mainly secondary pentanol with small amounts of tert-pentanol.

It was found that the yields of acids could be increased by extracting the acids from the reaction products and recycling the intermediate oxidation products along with the unoxidized pentane. With this method of operation the ratio of production of formic acid to acetic acid was greatly increased. This ratio was about 1 to 11.5 when operating without recycling of the alcohols and aldehydes and when these materials were recycled the ratio was 1 to 2.7.

Hexane

There is little information available in the literature concerning the partial oxidation of hexane. Some work carried out by Wheeler and Blair[11] indicated that the slow oxidation of hexane gives higher aldehydes, unsaturates (mostly ethylene), carbon oxides and water. Increased temperatures tend to reduce the yields of aldehydes and increase the production of acetic acid. It is believed that the proportions of oxygen in the reacting mixture were higher than would be desirable for the production of high yields of alcohols and aldehydes. The high oxygen concentration may also have accounted for the rather large amounts of unsaturated hydrocarbons present in the reaction products.

Heptane

A mixture of the heptane isomers, obtained from casinghead gasoline, boiling between 158-207°F. was oxidized by Wiezevich and Frolich[6]. The reaction was carried out at temperatures between 356-437°F. and at pressures of 135 atmospheres. Under these conditions the heptane fraction would remain in a liquid condition so that this is truly a liquid phase rather than a vapor phase oxidation. The products were primarily alcohols in the hexylheptyl (C_6-C_7) range, but there were produced smaller amounts of the lower alcohols, aldehydes, ketones and acids.

Mixture of Heptanes, Octanes, and Nonanes

Liquid phase oxidation of a petroleum fraction boiling in the range of 235-290°F. and consisting primarily of hydrocarbons containing seven, eight and nine-carbon atoms per molecule, has been found to produce rather high yields of acids.[12] The stock was prepared by extracting straight-run gasoline with liquid sulphur dioxide and fractionating the portion insoluble in the sulphur dioxide (raffinate) to obtain a material of the desired boiling range. This material was found to contain approximately 51 percent paraffin, 47 per-

TABLE 4
Yields of low molecular weight fatty acids produced by the liquid phase oxidation of C_7 to C_9 hydrocarbons
(Pressure, 7 atmospheres; temperature, 300-340°F.)

Acid	Production per 100 lb. (15.9 gal.) of charge consumed	
	Weight, lb.	Volume, gal.
Formic	9.0	0.88
Acetic	18.0	2.06
Propionic	4.5	0.54
Butyric	2.0	0.25

[11] T. S. Wheeler and E. W. Blair, *Journal of the Society of Chemical Industries*, 42, 491 (1923).
[12] Unpublished data, obtained by Union Oil Company.

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cent naphthene and 2 percent aromatic hydrocarbons so that the results obtained in this work are not directly comparable to those obtained with pure paraffin hydrocarbons. It is believed, however, that they might indicate the probable course of the oxidation reaction applied to a similar fraction of natural gasoline, particularly one containing naphthene hydrocarbons.

Briefly, the method of carrying out this type of liquid phase oxidation is to place the fraction to be oxidized in a reaction vessel where it is blown with air at elevated temperatures. The particular fraction referred to above was oxidized at temperatures of 300-340° F. under pressures of 100 lb. per sq. in. Under these conditions oxidation took place readily without the use of a catalyst.

The main products of reaction were acids although appreciable quantities of alcohols, aldehydes, ketones and esters were found in the reaction products. Water and carbon dioxide were always formed during the oxidation and resulted from the complete combustion of fragments of hydrocarbon molecules. It was found possible to separate the lower molecular weight fatty acids, in a relatively pure form, from the other products of reaction and the yields of those acids, per 100 lb. (15.9 gal.) of the hydrocarbon fraction oxidized, have been calculated. These yield data are shown in Table 4.

A mixture of low molecular weight alcohols, aldehydes, ketones and esters, which was readily separated from the oxidation products amounted to over 15 percent by weight of the hydrocarbon charge. A mixture of high molecular weight acids and esters, obtained as a residue from the oxidation vessel, amounted to about 38 percent of the oxidation charge. This fraction has been found to contain dibasic acids, and, in fact, appreciable quantities of pure succinic acid ($C_2H_4(COOH)_2$ have been separated from this mixture of acids by ordinary physical means.

The results of this work are of particular interest in that they show the possibility of converting a low-grade gasoline fraction into chemical products by means of a low-temperature, relatively low-pressure, oxidation process using air as the oxidizing medium.

Oxidation of Natural Gas

In the commercial utilization of oxidation as a means of producing chemicals from petroleum hydrocarbons it is probably advantageous to consider the use of mixtures of hydrocarbons rather than pure compounds due to the increased raw materials cost if separation of pure compounds were required. Narrow boiling range fractions are easily and cheaply produced in ordinary petroleum refinery equipment, and it is these fractions that are the most likely to be used in commercial oxidation processes. Dry or lean natural gas is an example of a fraction of petroleum that can be used without further processing. This material, as has already been pointed out, contains large proportions of methane but in addition contains ethane and propane and is a material that lends itself well to chemical processing because of its huge supply and low cost.

The first successful commercial plant utilizing natural gas as a raw material for the production of chemicals by oxidation is believed to be that of the Cities Service Oil Company at Tallant, Oklahoma. At this plant large quantities of methanol and formaldehyde are being produced, along with smaller amounts of other chemicals, by the controlled oxidation of natural gas. It has been estimated that this and possibly some other similar plants were producing between one-fourth and one-third of the total supply of methanol and formaldehyde in the United States in 1941.[13]

The development of the oxidation process by Cities Service Oil Company in the early part of 1928 was reported to have been the result of an investigation of a new treating procedure for natural gas designed to reduce pipeline corrosion. The corrosion was believed to have been due to the presence of small amounts of oxygen in the natural gas and in order to eliminate this oxygen additional quantities of oxygen (air) were added and the gas subjected to

[13] J. M. Weiss, *Chemical Industries*, 49, 348 (1941).

NIGHTFALL IN THE SAN JOAQUIN

A Word Picture by Julian Campbell

A setting sun midst bright cloud banks
Of brilliant rose on apple green
Which gives the silvered oil-field tanks
A lustrous iridescent sheen.

The high-lights soften, fade at last,
The eastern sky is steely gray;
The purple mountains darken fast
As restful night displaces day.

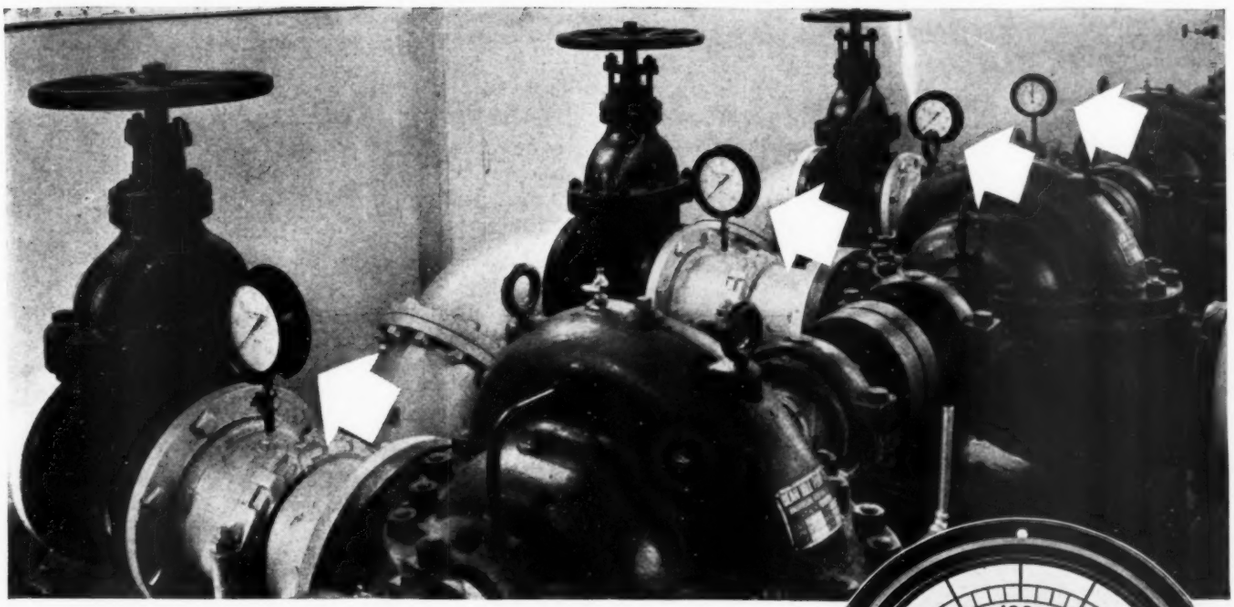
As after-glow of day's bright flame
The western brilliance lingers yet
To show each derrick's massive frame
In bold and sturdy silhouette.

While wafted on the night-born breeze
Comes clearly that familiar sound
Of busy grinding rotaries
That turn the bits far underground.

Soft plumes of work-exhausted steam
Reveal where crews of drillers toil
To wrest from Earth a goodly stream
Of Nature's hidden store of oil.

The moon behind Tehachapi
Now rises like a copper ball
It's dull glow brightens rapidly
To shed its mellow beams o'er all.

The scheduled stars come one by one
To faintly give their limpid light.
I call the passing day's task done
To sense the charm of desert night.



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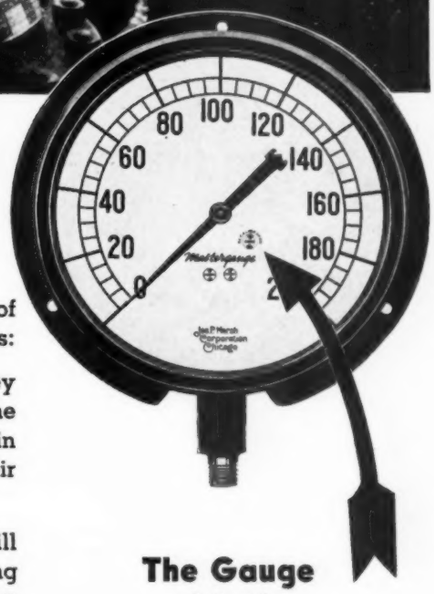

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pressure and high temperatures in order to initiate oxidation and thus remove all of the oxygen. The oxidation products were condensed from the treated gas and found to contain methanol, formaldehyde, acetaldehyde, and acetone.

The plant operations have been described briefly and a flow diagram for the operation appeared recently in the literature.[14] The operations are relatively simple and consist in compressing a mixture of natural gas and air and passing the mixture through a reaction zone at elevated temperatures. The reaction mixture is cooled on leaving the reactor and the liquid products are condensed and separated from the unoxidized gas. A portion of the gas stream from the separator is recycled, mixed with fresh feed and air, and further oxidized. The conditions of operation are not disclosed, and it is not known whether catalysts are used, but is believed that the process is catalytic. It is stated that the temperatures and pressures are low as compared with the temperatures and pressures required in many high-pressure syntheses. Presumably, equipment costs for such installations would not be excessive. In this connection it is believed that ordinary steel equipment is all that is required as the proportion of acids in the products is very low.

Methanol and formaldehyde are the main products of this plant and these compounds are produced in approximately equal proportions. In addition to these two compounds there is produced an appreciable quantity of acetaldehyde and smaller amounts of acetone. In separating the reaction products, an initial rough separation is made and these impure products are refractionated to produce the materials of commercial quality. Methanol and acetaldehyde are separated as pure compounds, formaldehyde is produced as a 40 percent solution in water (formalin), and acetone, which is difficult to separate from mixtures containing methanol, is produced as so-called methyl acetone. This latter product is a mixture of methanol and acetone containing approximately 15 percent of the former and is a valuable commercial solvent.

[14] *Chemical and Metallurgical Engineering*, 49, No. 9 154 (1942).

Market for Oxidation Products

When Cities Service Oil Company first began producing methanol and formaldehyde there was an abundant supply of both of these products. Methanol was being produced by a high-pressure catalytic process from carbon monoxide and hydrogen, and formaldehyde was being produced by the catalytic oxidation of methanol. Although at first the production of these two commodities from natural gas did not appear to be justified on the basis of market conditions there shortly arose a new large utilization for the formaldehyde, and indirectly the methanol: its use in the synthetic resin industry. This new and fast growing industry was able to use all of the formaldehyde available.

The large consumption of formaldehyde by the synthetic resin industry is easily understood when it is realized that formaldehyde is used in the production of about one-half of the molded plastics manufactured in the United States. These plastics include the phenol- and cresol-formaldehyde plastics, such as Bakelite; the urea-formaldehyde plastics, such as Beetle and Plaskon, and the casein plastics, such as Ameroid. Due to the present large use of plastics in war production, there is a shortage of both formaldehyde and methanol. Formaldehyde was one of the first chemicals to be placed on a mandatory priority basis; this control being instituted in August, 1941.

The shortage of both of these chemicals has been due in part to the conversion of the large du Pont methanol plant at Belle, West Virginia, into an ammonia plant as a war production measure. The reason for this conversion is apparent when it is realized that both the synthetic methanol process and the ammonia process require high-pressure equipment that is difficult to build with the present demands on steel. It appears, therefore, that much of the formaldehyde produced to meet the war emergency will be produced at plants similar to the one at Tallant, Oklahoma, and it is presumed that more of these plants are being, or will be constructed in the near future. It has been predicted that even though more natural gas oxidation plants are built to meet the war demands the natural gas process will be able to maintain its position after the war.[13] This prediction is based on the belief that the plastics industry is destined to even further expansion and to the belief that the high-pressure catalytic methanol processes may find it difficult to compete with the cheaper natural gas process.

Future Developments

The petroleum industry has seemingly been slow to realize and to capitalize upon the fact that their basic raw materials, crude oil and natural gas, can be profitably converted into chemical products. This reluctance to enter the chemical field can be traced to several fundamental factors:

1. The industry has been so engrossed in producing huge quantities of crude oil and refining this material at a profit that consideration of chemical outlets, which at best would utilize relatively small amounts of petroleum, has not seemed desirable.

2. The costs of plants required for chemical production are, in general, far greater than the usual refinery construction costs.

3. The rapidly changing character of the chemical market makes it imperative that a manufacturer be ready to convert his plants and processes to meet the changing conditions. Thus, chemicals that today are novelties and of little commercial value, may tomorrow be required in large quantities, and others, which today are being used in large amounts, may be displaced tomorrow by better or cheaper substitutes.

The petroleum chemical industry has a sound basic position because of its control of the cheapest source of hydrocarbon raw material and its future development will depend upon the ability of the personnel of this industry to improve upon present known methods and develop new methods for chemical processing.

☆ ☆ ☆

Average Accident Frequency Rate

The average accident frequency rate for participants in the National Safety Council's 1941-42 Petroleum Section safety contest was 3 percent below that for the previous contest, despite a larger number of competing companies than ever before.

The average frequency rate for all contest divisions was 8.88 reportable injuries per 1,000,000 man-hours worked.

Manufacturing units had the lowest rates, averaging 5.42. Drilling units had the highest rates with an average of 41.68.

Frequency rates for the seven contest divisions and the change from the previous contest follow:

Division	*Average frequency rate*	*Percent change from 1940-41 contest*
Manufacturing	5.42	+ 8
Natural gasoline	7.25	+16
Wholesale marketing	7.80	— 4
Oil and gas pipe line	8.53	— 3
Retail marketing	13.32	— 8
Producing	13.54	+ 1
Drilling	41.68	— 5

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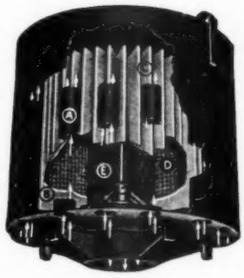

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Wildcat Drilling in California

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☆ **Discovery of new fields in recent years has been insufficient to maintain state's available oil reserves**

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

THE oil industry of California is of vital importance to Pacific War operations and, because it is a major source of fuel for war production plants situated in the state, it affects the war effort of the entire country. The petroleum situation that has developed in California during the last year is not, however, encouraging from the standpoint of future reserves. A few small fields have been discovered and extensions have been made to some of the existing producing areas. The general condition of the industry in the state is graphically presented by the production and drilling curves shown in Fig. 1, in which it will be noted that during the last year production increased and drilling decreased.

The picture is actually worse than disclosed by this graph. Curves showing both active drilling wells and producers completed indicate an increase after the middle of the year, but most of the wells completed during this period have been shallow wells drilled in proved areas to augment the supply of heavy oil that is of immediate necessity to meet the demand for fuel oil. These have been more or less emergency wells and will serve to deplete the heavy oil reserve, which is not too extensive.

It is true that light oil production has not yet been stepped up to its maximum rate of effective recovery. It is also true that precautions are being taken to produce efficiently with the greatest conservation of gas. On the production of light oil depends the big percentage of natural gas, which is the chief fuel of the widely expanded industries of the state, particularly in Southern California.

The maintenance of the natural gas supply has been given intelligent attention during the year. Transportation was an immediate problem but fortunately the Rio Vista gas field provided a supply for San Francisco and the Bay Area and permitted the conversion of a large-diameter gas line into a much needed oil line extending from San Joaquin Valley to this area. This rearrangement of facilities necessitated the construction of only a relatively short line to carry the gas from the field to the industrial area around San Francisco Bay.

Although operations were too late to provide much storage before winter weather arrived this year, one partially depleted oil field near Los Angeles was allocated for storage of gas in the oil zone to insure the supply of fuel for the Los Angeles and San Diego areas.[1] This will reduce the demand for dry gas next winter and make certain that an adequate supply is available should an extreme emergency arise. There is very little wastage of gas in California but the storage provided by this field will make the wastage even less than it is now by putting gas in underground storage during the summer months when all the gas produced with oil may not be utilized because of lack of storage facilities.

[1]This project was described in "Underground Gas Storage Project in California," *The Petroleum Engineer*, December, 1942.

From the curves in Fig. 1 can be observed the excellent effect of voluntary curtailment during the two-year period beginning early in 1939. Because of the demand for more oil, production was increased and during the last year requirements of the OPC augmented the state's allotment to more than 700,000 bbl. per day. During this time, and beginning at the high in the middle of 1337, the number of active drilling wells has steadily declined until the number has fallen below the low point of the depression. Actually, drilling activity during the years of controlled production remained comparatively steady.

During the years 1939 to 1942, inclusive, the discovery of new fields and extensions to proved areas was not great enough to maintain the known reserve, much less increase it. The drilling of exploratory wells did not, by any means, stop during that period but the number did decline. Wildcat drilling the last year has been restricted by material shortages, but economic factors have also had an adverse influence on the

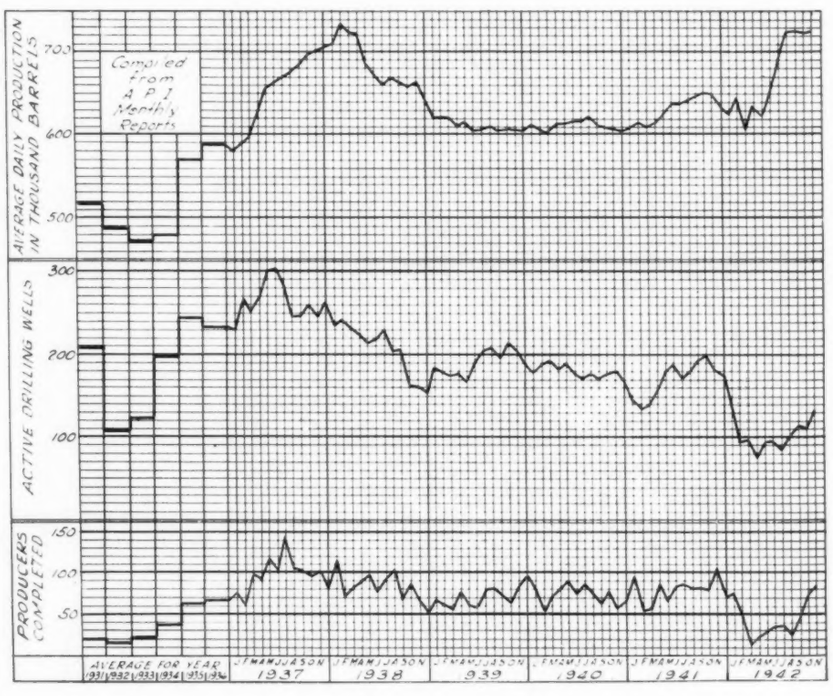
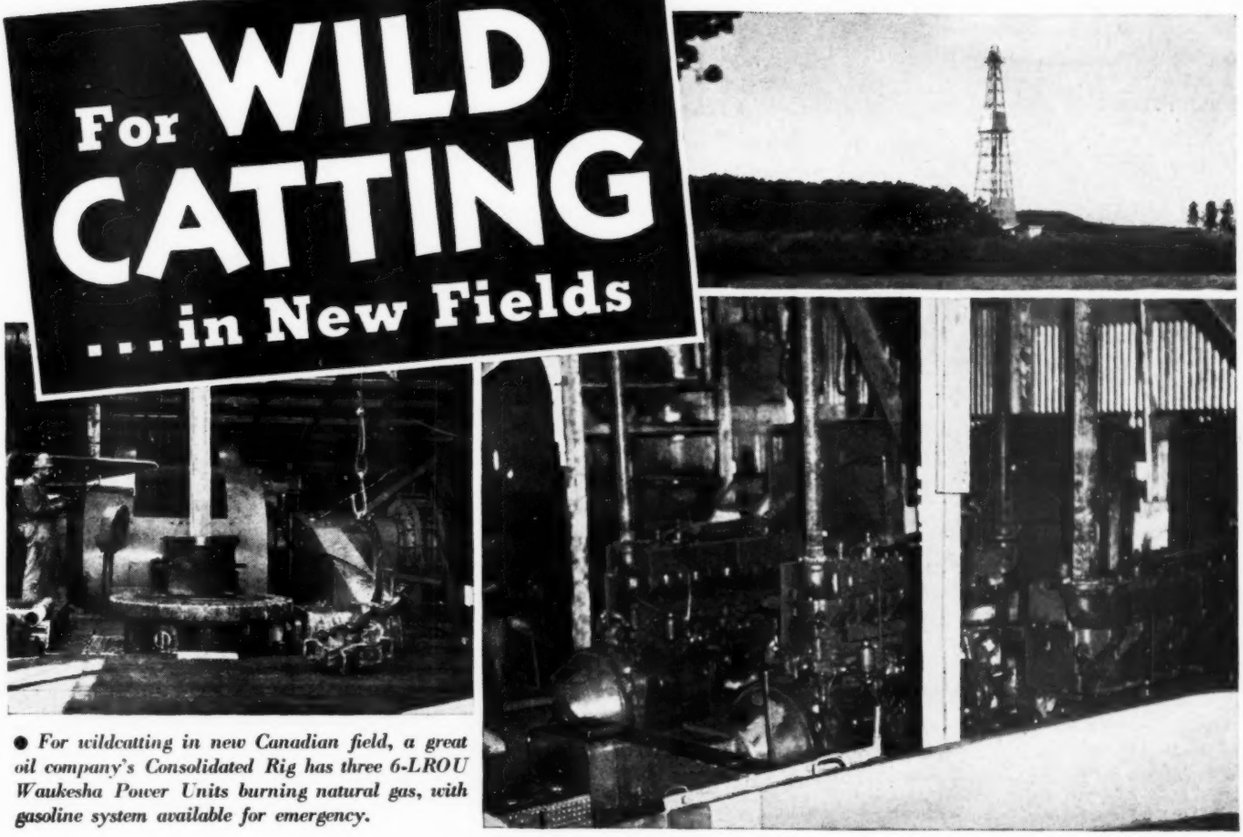


Fig. 1. Curves showing production and drilling activity in California

For WILD CATTING ...in New Fields



● *For wildcatting in new Canadian field, a great oil company's Consolidated Rig has three 6-LROU Waukesha Power Units burning natural gas, with gasoline system available for emergency.*

WAUKESHA *Oil Field* ENGINES

Convertible from Natural Gas to Gasoline ...without interrupting operations

★ Wildcatting in a new field—one of Canada's foot-hill regions noted for its consistently hard formations—these engines have drilled 2500 to 2600 ft. in what is expected to be an 11,000-ft. hole.

At least 250 to 400 bits will be used and six months to a year will be required, if this drilling project is completed as planned.

This oil company is using one of the best equipped, best rigged up mechanical power rigs of the larger type. It's an Ideal Type 125 Consolidated Rig, with three big Model 6-LROU Waukesha Oil Field Power Units, 8½" x 8½", 2894 cu. in. displ., developing 375 to 400 hp. *each.*

Coupled through hydraulic transmission to the mud pumps, rotary table and draw works, these Waukesha Engines give all the responsive smoothness, with fast flexible power, that deep drilling demands . . .

And more! These Waukesha Power Units burn natural gas. But, in new fields like this one, the supply of natural gas often runs short. It happened here. And butane wasn't available either. But these Waukeshas are *Multi-Fuel* Engines—with a gasoline system immediately available. Drilling went right on without interruption. *Get Waukesha Oil Field Engine Bulletin 1079.*

WAUKESHA MOTOR COMPANY, WAUKESHA, WIS., NEW YORK, TULSA, LOS ANGELES

drilling of exploratory wells. Several new fields have been discovered in 1942, however, and extensions made to proved areas of others.

New Producing Areas

Although actually discovered a week or two before the beginning of the year, the Riverdale field in Fresno County can be considered one of the new California fields of the last year. Amerada Petroleum Corporation's discovery well, 45-26 in this field, was drilled to 8311 ft. with 11¾-in. casing cemented at 643 ft. and 5½-in. at 8116 ft. The lower zones tested wet, however, so the hole was plugged back to 6800 ft. and perforated from 6665 to 6685 ft. A 2-in. tubing string was set at 6625 ft. and the well produced 558 bbl. per day of 34.0° A.P.I. oil through a 16/64-in. bean with 1,375,000 cu. ft. of gas. A number of wells have since been completed at the 6800-ft. depth during the year.

The discovery in May of the Williams field by Shell Oil Company, Inc., increased the heavy oil reserve of the state to some extent. The discovery well was Williams 45-6 located just southwest of the North Belridge field in the Antelope Hills area and, drilled to a total depth of 2340 ft., came in with an estimated initial of 1725 bbl. per day of 16.5° A.P.I. oil with no water. The volume and pressure of gas was small. The casing consisted of 317 ft. of 9⅝-in. and 2280 ft. of 6⅝-in. An 86-ft., 5½-in. liner with 60 ft. of perforations was landed on bottom and 3-in. tubing was set at 2268 ft. with a packer at 2182 ft. Water appeared and after increasing to 70 percent, the well died. A water witch was run and located a major water entry at 2280 ft. and a minor entry at 2305 ft. The 5½-in. liner was fished out, the hole bridged at 2285 ft., and the shoe of the casing recemented. After cleaning out, 87 ft. of 5½-in. liner with 55 ft. of perforations was landed on bottom and 3-in. tubing set at 2269 ft. with packer at 2175 ft.

The structure of the Williams field is a sharp anticline. Several wells have been completed and the productive area is believed to be somewhat less than 1000 acres. Deeper zones, such as the Wagon Wheel and Eocene, may be productive but no test of these zones has been made to date.

In the Anaheim-Buena Park area The Texas Company obtained a small well with its Spencer No. 1. Since then one other well has been completed and a third is drilling. The discovery well was put down to 9660 ft., 11¾-in. casing being cemented at 1196 ft. and 5½-in. casing cemented on bottom. The well was then perforated and tested up to 8900 ft. but the lower zones were either wet or made little oil. Perforations, except those from 8900 to 8932 ft., were squeeze-cemented off and 2½-in. tubing then set at 8833 ft. The hole was plugged back to 8960 ft. and the well made 137 bbl. gross per day of 21.2° A.P.I. oil. The second well was drilled to 10,044 ft. After testing, a bridge plug was set at 9325 ft. and the casing gun-perforated from 9240 to 9315 ft. The highest production from this well was 402 bbl. gross per day of 23.0° A.P.I. oil cutting 7.0 percent. Production of oil has since declined and the volume of water increased.

Of considerable interest was the extension of the Paloma field by General Petroleum Corporation's well Gallaher 61-33 approximately a mile north of the field. The oil from this well, however, was 34.4° A.P.I. in contrast to the 50° to 55° A.P.I. oil and high gas-oil ratio of the area previously produced. The well was carried to 11,043 ft. with 13⅜-in. casing cemented at 1266 ft. and 7-in. casing at 11,000 ft. On a formation test of the open hole below the casing a heavy flow of oil and wet gas blew out 3048 ft. of water cushion and the tail piece was lost. After side-tracking and redrilling to bottom the 7-in. casing was tested for water shut-off. Two-inch tubing was then set at 10,899 ft. The well was completed "barefoot" with a gross initial of 422 bbl. per day through a 16/64-in. bean with 550,000 cu. ft. of gas. The tubing pressure was 1075 lb. per sq. in. and the casing pressure 1150 lb. per sq. in.

Tide Water Associated Discoveries

In November Tide Water Associated Oil Company completed its Sesnon No. 1 at a depth of 9086 ft. to discover a westerly extension to the Aliso Canyon field. The casing program included 731 ft. of 13⅜-in.; 6332 ft. of 9⅝-in.; 8670 ft. of 7-in., and 282 ft. of 5-in. liner with 249 ft. of perforations set at 8907 ft. Initial production was estimated at 2393 bbl. per day of 23.1° A.P.I. oil with more than 1,000,000 cu. ft. of gas. Oil production is from upper Luisian rock and from closure against a fault. The productive area has not been estimated. Production differs from that of the company's well Porter No. 12 in the adjoining section although the Sesnon well was completed in the same zone. The Sesnon well was directionally drilled and is considerably down dip from the bottom of Porter No. 12, which is more prolific and is producing 40° A.P.I. oil.

Although it is too early to make definite predictions, there are strong indications that Tide Water Associated's well KCL No. 56-8 has discovered a new field east of the Strand field in Kern County. The hole attained a depth of 8207 ft. with 18⅝-in. casing cemented at 190 ft., 13⅜-in. casing at 812 ft., and 7-in. casing at 8100 ft. Initial production was 1553 bbl. per day of 33.8° A.P.I. oil through a 1-in. bean with 1,250,000 cu. ft. of gas, tubing pressure of 500 lb. per sq. in., and casing pressure of 1100 lb. per. sq. in. The well is on a seismograph high similar to the Strand field and the structure is a quaquaversal anticline. The area of the field has not been estimated but it will probably be small.

Extremely heavy oil production was discovered in the Tide Water Associated well Davis No. 1 on Rancho Corral de Quatti (Carranza Mesa Tract) north of Los Olivos in Santa Barbara County. The field will probably be called Zaca. The oil is 9 to 10° A.P.I. and in producing this low gravity oil it is necessary to thin it with distillate in order to lift it to the surface of the ground by pump. It is, however, considered an excellent road oil. The well was drilled to 6643 ft. and plugged back to 5956 ft. Casing consisted of 526 ft. of 13⅜-in. and 4615 ft. of 9⅝-in. A 1381-ft. liner with 1320 ft. of perforations was set at 5950 ft. Initial production was approximately 20 bbl. per hour. The structure is anticlinal and production is from fractured siliceous shales in the Miocene. The well will be pumped for some time before plans for further drilling are made.

Gas Fields

The Bowerbank gas field discovered near the Buttonwillow field during the last year is fortunately near existing gas transmission systems and thus provides additional natural gas with little pipe line construction. The discovery well, The Texas Company's S.P. 47-15, was originally drilled in 1941 to a depth of 12,138 ft. in search of oil. This hole was cased with 1204 ft. of 13⅜-in. and 8932 ft. of 8⅝-in. A 5108-ft. string of 5½-in. liner was landed on bottom. After testing, the hole was plugged back to 6607 ft. and operations then suspended. On going back into the hole during this last year it was cleaned out to 4271 ft. and there plugged. Perforations were made from 4253 to 4262 ft. and 2½-in. tubing set with packer at 4171 ft. The estimated production is 11,000,000 cu. ft. per day.

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Refinery Practice for the Operating Man

Vocational Class Proceedings in Refinery Engineering

Manufacture of Lubricating Oils

Class Meeting No. 6

NOTE: Throughout the class proceedings, no attempt is made to distinguish the identity of the pupil speaking. When a series of remarks is made by pupils it usually denotes an interchange of discussion among the class members themselves.

Leader: The following statements were made during the previous meeting:

(1) The solubility of oil in propane decreases as the temperature increases.

(2) The solubility of asphalt decreases as propane is added to an asphaltic base oil. (There is also more precipitation.)

(3) Pressure has a marked effect on solubility.

(4) Compressed propane gas at certain temperatures will dissolve more oil than liquid propane at slightly lower temperatures and pressures, and that statement indicates a very interesting phenomenon. Will someone give a discussion of that phenomenon?

Pupil: Retrograde condensation, by definition, means natural gas laws reversed. If temperature and pressure are increased, the dew point is reached when the liquid changes to a vapor. At this point there is a "balance." With a molecular component system it is different. If there is a range where both liquid and gas exists, this range is called the parameter line. The line is plotted where the liquid is beginning to form gas. The other line plots the vapor as it is forming. As we look at Fig. 9[1], we may get an idea of what happens: The C_1 point indicates the maximum temperature at which a liquid may be condensed from a vapor. The liquid phase and vapor phase are identical. Point F on the graph is the highest temperature at which any liquid can exist. If the critical temperature is passed for any specific mixture, no liquid can be obtained from it, regardless of pressure.

We are going to hold the temperature constant and increase the pressure. We have all vapor and as we increase the pressure to a point about F on the graph, we are getting liquid condensed at this point. Keep on compressing and you begin getting less and less liquid until you get to C_1 and you have a completely vaporous condition. If you hold the pressure constant, and reduce temperature, retrograde condensation will occur.

Pupil: Where is the critical temperature on the graph?

Pupil: F. *The Petroleum Engineer* has published an interesting discussion[1] on condensate wells and goes into retrograde condensation thoroughly. There are two types: (In Fig. 9) C_1 is that point at which you have the same quality for liquid and gas. Draw your parameter lines as in Fig. 10. C_1 temperature is the same as F in Fig. 9—or the critical temperature. The same thing takes place in isothermal compression. With some hydrocarbon mixtures, at low temperatures it is that exactly. We come to parameter line as shown in Fig. 11. This is liquefying by vaporization and the condensation point of the vapor meets here. Here C_1 is the critical temperature. This is called retrograde condensation of the second type; sometimes called retrograde vaporization.

Pupil: Do the drawings as shown correspond?

Pupil: They can be made to. They are all isothermal.

Pupil: If, at a certain temperature, you would have a vapor stage to the parameter line, the temperature could be increased to form a liquid, and vice versa?

Pupil: Yes. In wells where gas is produced for cycling plants, the same thing happens when pressure and temperature are such as to give retrograde condensation.

Leader: This was found accidentally?

Pupil: The use was found accidentally, in Germany, in 1890. The condensate wells are, I believe, the first attempt to use this principle commercially. *The Petroleum Engineer* article states that if you have two hydrocarbon molecules and some water in a mixture, at a certain range you will also have separation of a liquid, as well as liquid

(Continued on Page108)

[1]Figs. 9, 10, and 11 are taken from the article "Physical Properties of Hydrocarbon Mixtures in Condensate Production," by Frank H. Dotterweich, *The Petroleum Engineer*, February, 1941.

Fig 9. Pressure-temperature relations at constant composition for mixtures of components X and Y

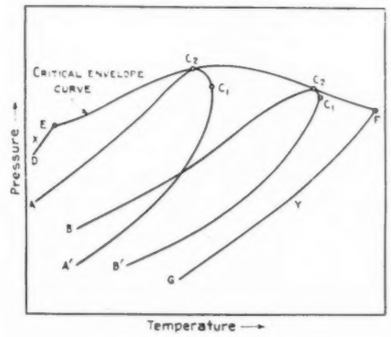


Fig. 10. Retrograde condensation, first type

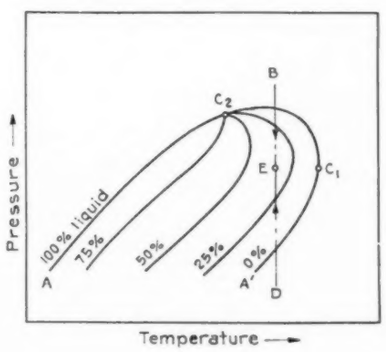
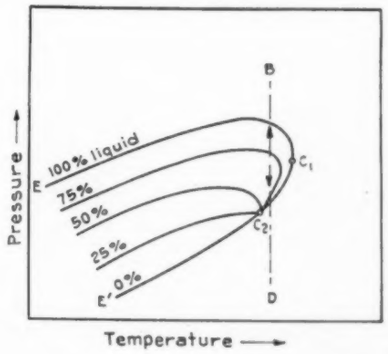
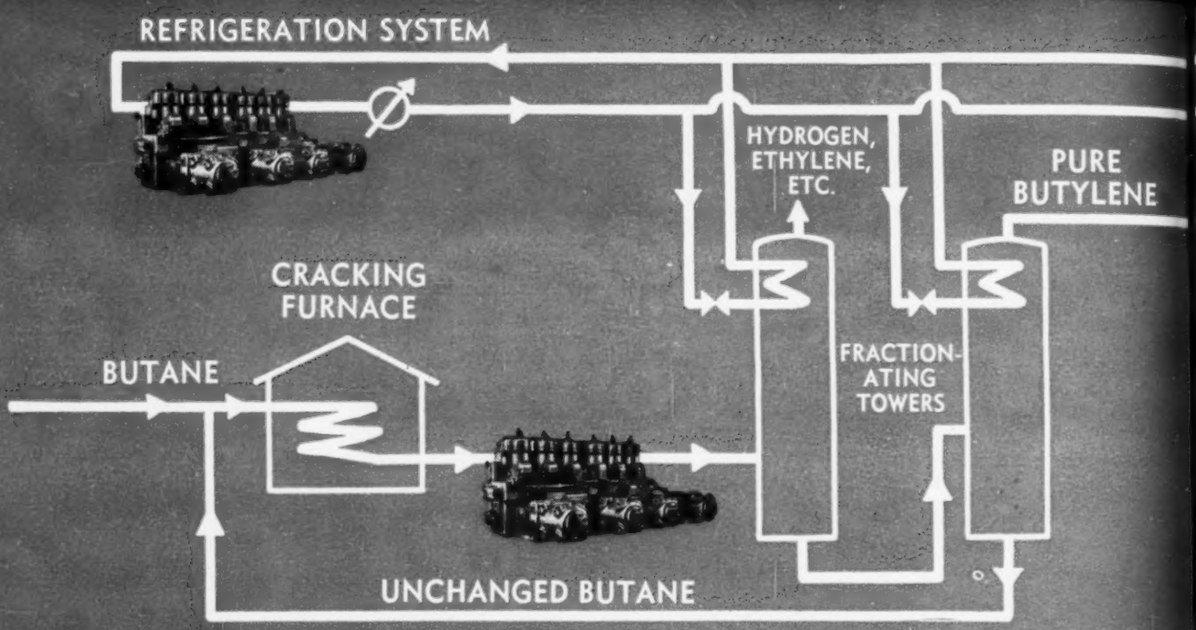
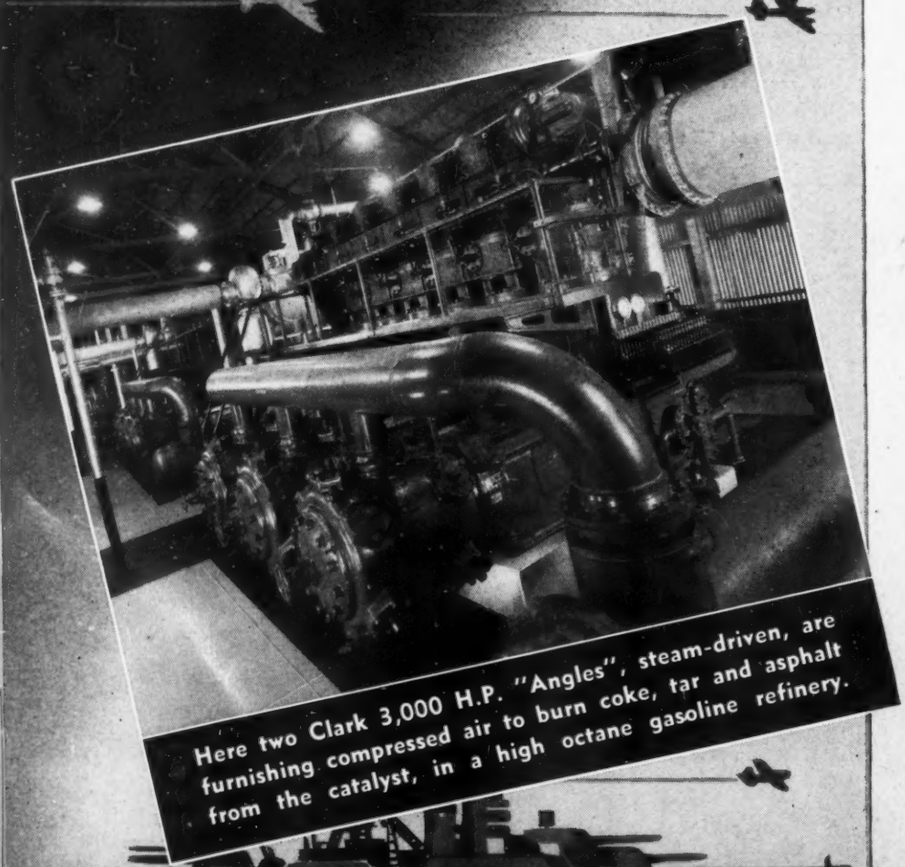


Fig. 11. Retrograde condensation, second type



CLARK COMPRESSO





Here two Clark 3,000 H.P. "Angles", steam-driven, are furnishing compressed air to burn coke, tar and asphalt from the catalyst, in a high octane gasoline refinery.

AMONG the scores of processes so far developed in making synthetic rubbers of the various types — one of the heavy volume roles will be that of the manufacture of Butadiene, the petroleum product from which the Buna N and Buna S types of rubber for automobile tires will be produced.

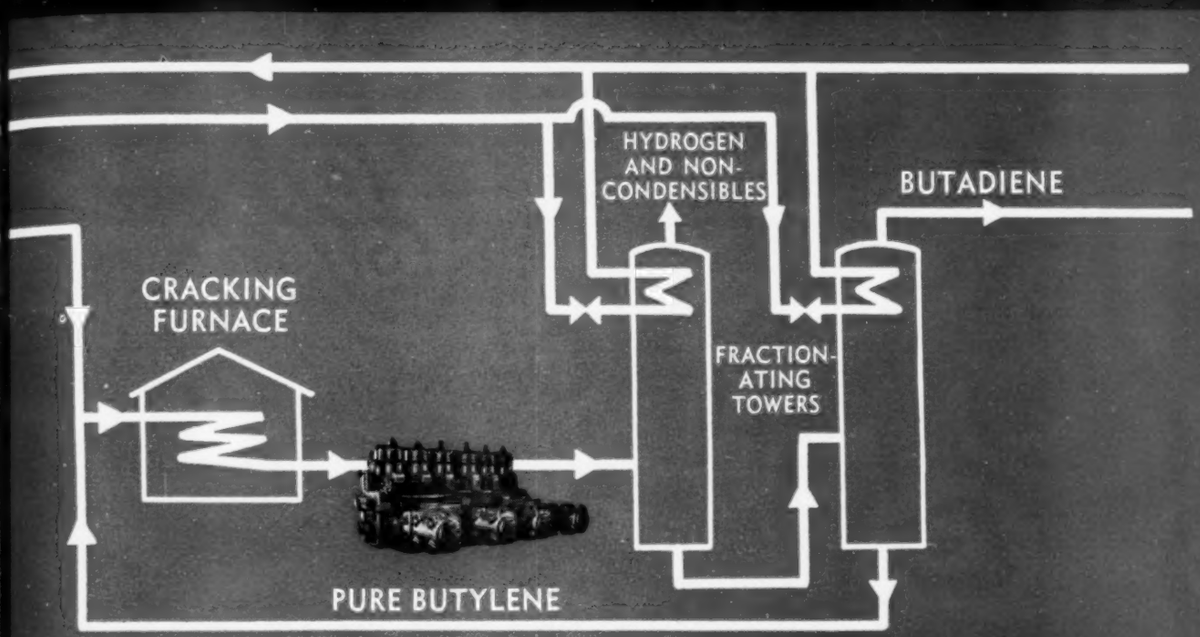
The simplified flow chart shown above indicates the part that CLARK Compressors will play in many leading Butadiene plants. They will be used for compression of gases for charging the fractionating towers and for refrigeration.

These processes are typical of the services that CLARK Compressors are being called on to perform in all types of synthetic rubber plants. In one type of plant CLARK Compressors will produce temperatures in the neighborhood of 150 degrees below zero.

CLARK Compressors are also used in the manufacture of Styrene from petroleum—the

CL

SORS *for* BUTADIENE



material which is combined with Butadiene to form Buna S Rubber. They are also in tremendous demand for many war industries not connected with rubber. They perform major operations in the manufacture of high octane gasoline, high explosives, synthetic alcohol, synthetic ammonia, and many other chemicals and materials needed for the war production program. Clark engineers have had intimate contact with these war industries from the start and understand their compressor problems. Call them into consultation.

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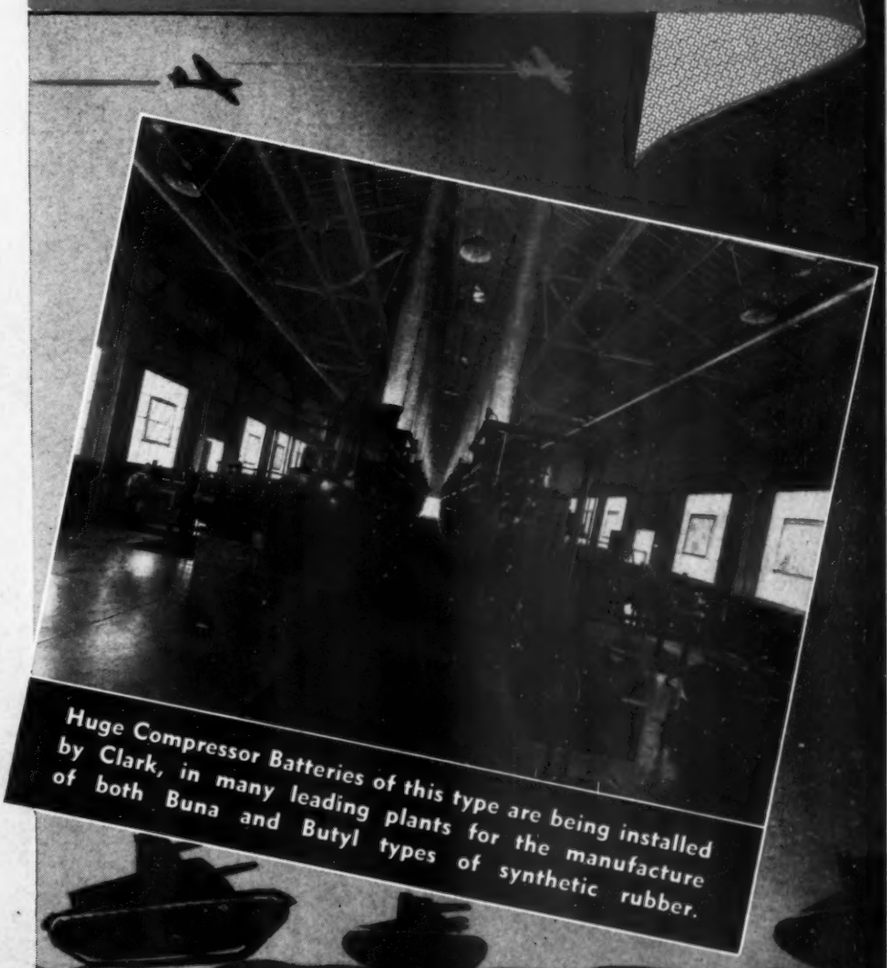

Huge Compressor Batteries of this type are being installed by Clark, in many leading plants for the manufacture of both Buna and Butyl types of synthetic rubber.

(Continued from Page 105)

and gas. This is double retrograde condensation and often happens in wells.

Pupil: Then retrograde condensation depends to a great extent upon mixtures of widely different gases? Will propane and ethane occur in retrograde condensation?

Pupil: Probably so—the break would be distinct.

Pupil: Does each separate component have its own pressure and temperature?

Pupil: No. You have two component systems.

Leader: I suggest that if you have not done so, please study page 97 of your text.[2]

Pupil: The interesting thing is that if you hold the pressure constant and decrease the temperature, you would expand to far more gas but you would probably get liquid. So long as you compress on this side of your equal compression point you have a dense system of complete solubility.

Leader: We have asked one of our members to give a discussion of the methyl ethyl ketone system.

Pupil: We will not be able to go any further than we did at the last meeting with this system. The system was developed by The Texas Company and has been in operation, in Illinois, since 1927. Acetone is used, usually, as the precipitating agent because of its ability to precipitate wax in very definite crystalline form on distillation, making it easy to separate by filtration, or pressing, and acetone will dissolve but very little oil. It is necessary to use some other solvent in connection with acetone to dissolve the oil; benzol is one material that can be used. Benzol and toluene are usually used, sometimes in mixture. Mixtures of methyl ethyl ketone and di-ethyl ketone are also used instead of acetone.

One advantage of using this process is that the finished oil comes out bright and free from wax and has a relatively low pour point without a great deal of attention to chilling. Five degrees of differentiation is possible. If you want zero pour point, you can go to 5 deg. In actual practice there is probably some difficulty at this point.

As to the process itself: Chilling rates do not seem to be critical as they can be lowered from 100 to 0 in a short time (from 1 to 3 hours is the usual time) and this is an advantage as you don't have to watch the chilling rates. There are several things to "juggle" in this process to obtain low pour point material.

The maximum yield of oil of a given pour test can be obtained by using larger quantities of benzol or toluene. For high filtering rates you need high acetone content. In order to get good pour point material and high oil yield it is necessary to strike a happy medium in the chilling temperatures and quantities of ketone, benzol, and toluene. I have a rough flow sheet diagram of the process showing the solvent and oil mixed and passing through an exchanger. (See Fig. 12) The oil is forced through the exchangers and the chillers with a pump but no pumping takes place between the chilling process and the filters to avoid destroying the crystalline structure. The solvents in the oil are mixed and passed on to filters. I believe the installation at Lawrenceville, Illinois, uses a rotary-type filter. The wax is removed from the filters, washed with cold solvent to remove oil, and is warmed by heaters and put through the separators. The ketones are recovered. The wax is taken through a series of exchangers to the wax distilling tower where the solvent is flashed off. The wax is put through a steamer and goes to storage. The oil from the filter comes off in two separate stages; part in the wash from the cake, the other as it is filtered. It is then taken back to the receivers and the solvent flashed off and the oil taken over to the steam stripper and discharged.

EDITOR'S NOTE: To be continued in an early issue of *The Petroleum Engineer.*

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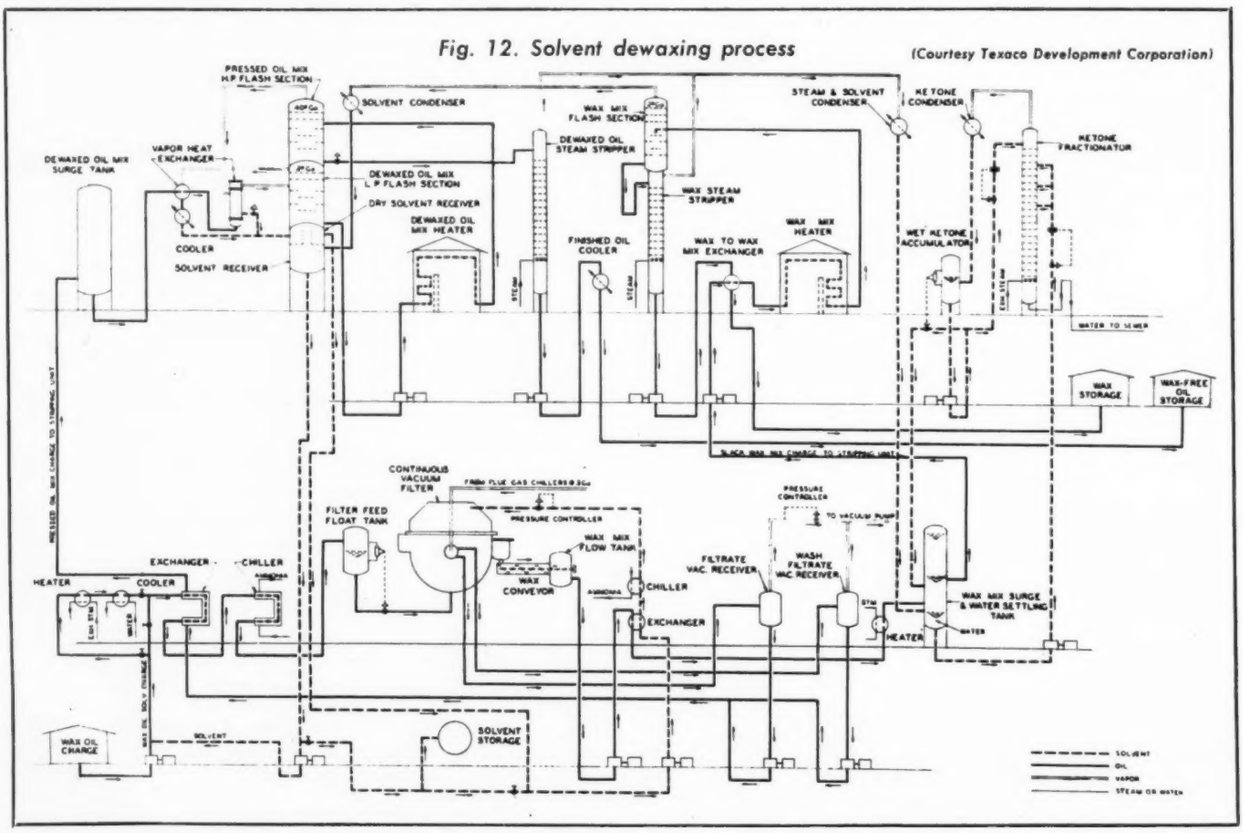
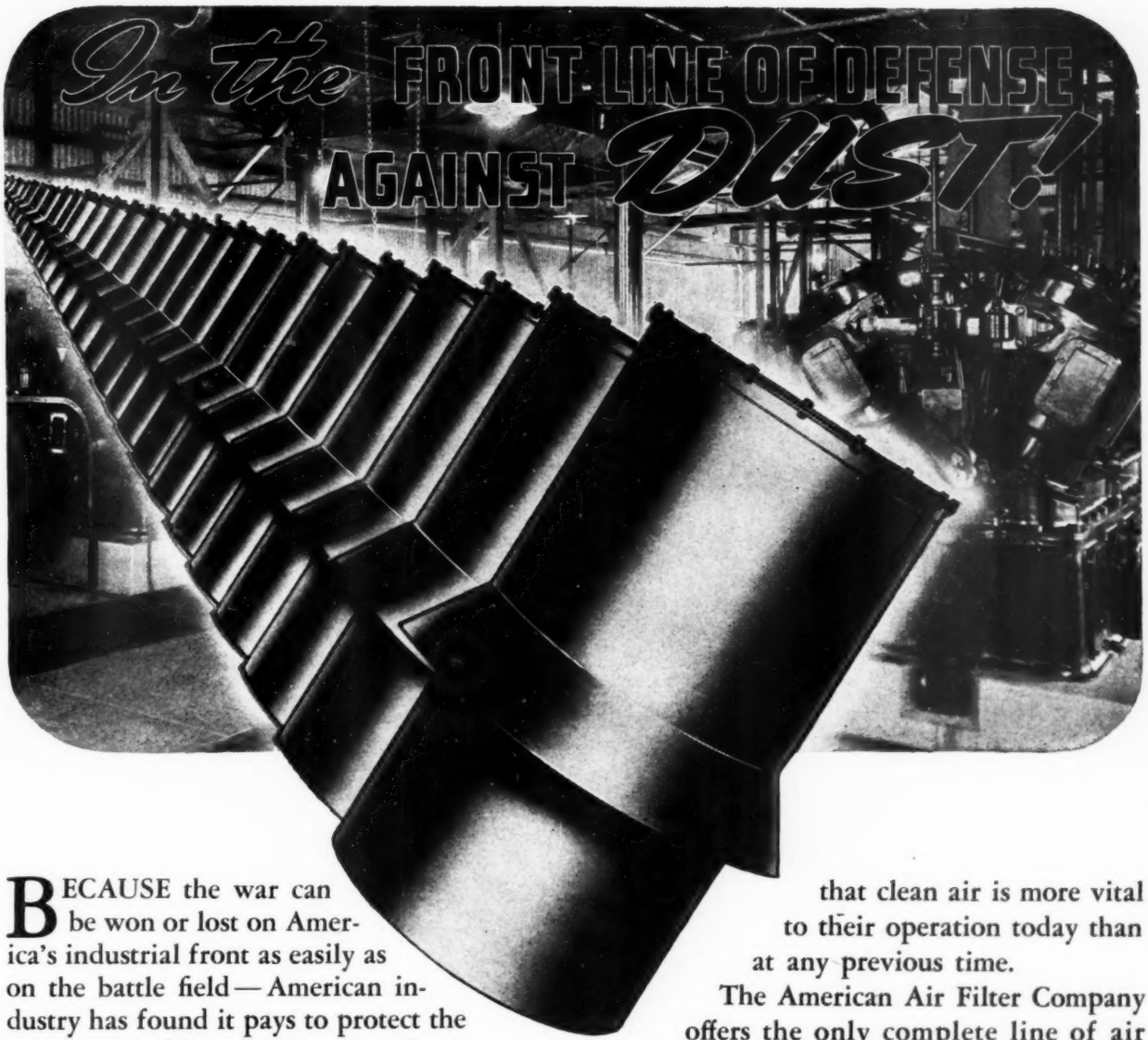
[2]Modern Methods of Refining Lubricating Oils, by Vladimir A. Kalichevsky.

Fig. 12. Solvent dewaxing process (Courtesy Texaco Development Corporation)





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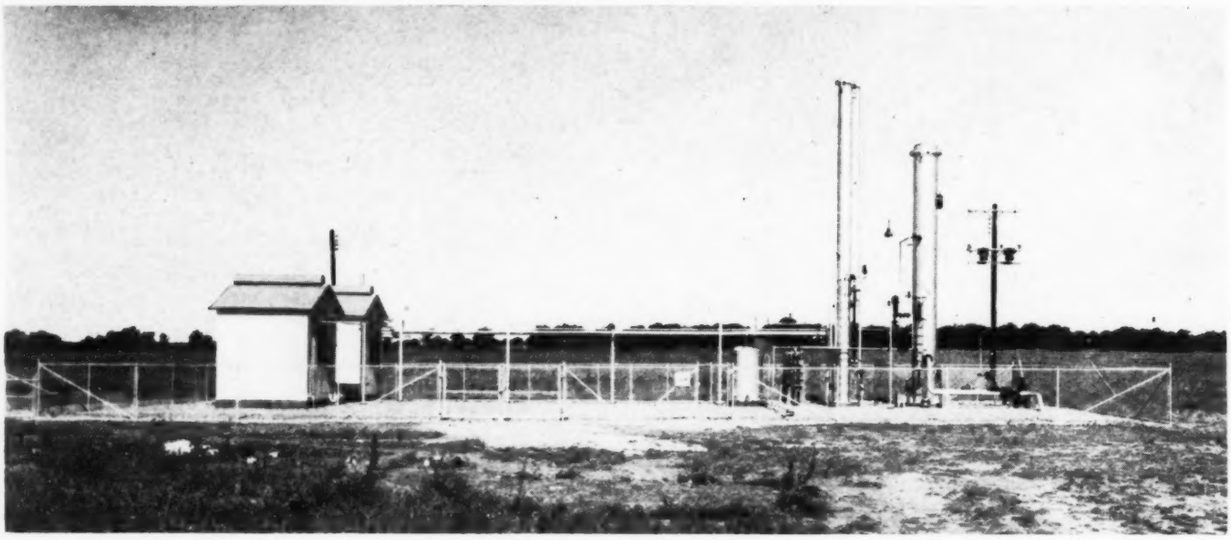

Glycol dehydration plant that conditions 60,000,000 cu. ft. of gas per day

Dehydration of Natural Gas

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☆ **Although all dehydration plants have a basic function, designs vary according to conditions**

by Roy W. Parker
Oklahoma Natural Gas Company

STATISTICAL information reveals that in the 12 months ending June 3, 1942, the sales of natural gas totaled 931,814,400,000 cu. ft., which is an increase of 11.6 percent from a year ago Comparable yearly gains have been reported for several years. The greater part of these increases had to be handled by existing or recently completed transmitting facilities, which in many cases necessitated higher operating pressures. With these increased pressures came additional operating problems to be considered if potential demands were to be satisfied. Not the least serious was the increasing difficulties encountered by ice or hydrate formation at these elevated pressures, which caused line stoppage and interrupted service.

By hydrate formation is meant the formation of crystalline compounds of water and gas, which under pressure exist at temperatures varying from 34°F. at 110 lb. per sq. in. to 64°F. at 1000 lb. per sq. in.

Dehydration, or the elimination of entrained water vapor, is reported[1] to have begun in 1926. The first complete gas-dehydration plant, which employed a brine solution, was installed at the Grand Rapids Gas Light Company in mid-summer of 1928. In the intervening years the engineering personnel of gas companies and U. S. Bureau of Mines engineers have applied their technical knowledge and skill in a study of gas hydrates and their relation to the operation of natural gas pipe lines. These studies and resultant data have appeared progressively in the trade journals and have aided materially in correcting many of the objectionable difficulties that have arisen in this phase of the gas business.

ROY W. PARKER

has been in the employ of the Oklahoma Natural Gas Company for about 17 years, serving in the measurement department, the meter repair department, as assistant chemist, as chief chemist, and now as industrial sales engineer—Prior to his affiliation with Oklahoma Natural he had been employed in the refining department of The Texas Company, from 1923 to 1926—He is a graduate of Southeastern State College.

Advantages of Dehydration

The advantages of gas dehydration are well known and can be summarized as follows: First, increased line capacity by preventing clogging with condensed water, eliminating partial or complete stoppage due to freezing; second, retarding of internal corrosion, which in time might be responsible for excessive leakage or line ruptures; third, alleviation of dust problems in distribution systems, and fourth, elimination of drips and their associated expense and gas waste in blowing.

With a full realization of the problems confronting them it was only natural that a wide diversity in plant design and corrective methods should be evolved by technical staffs. Fundamentally, the same results were sought, but

[1] W. L. Shively, Koppers Company, *Gas Age Record*, p. 45, October 26, 1939.

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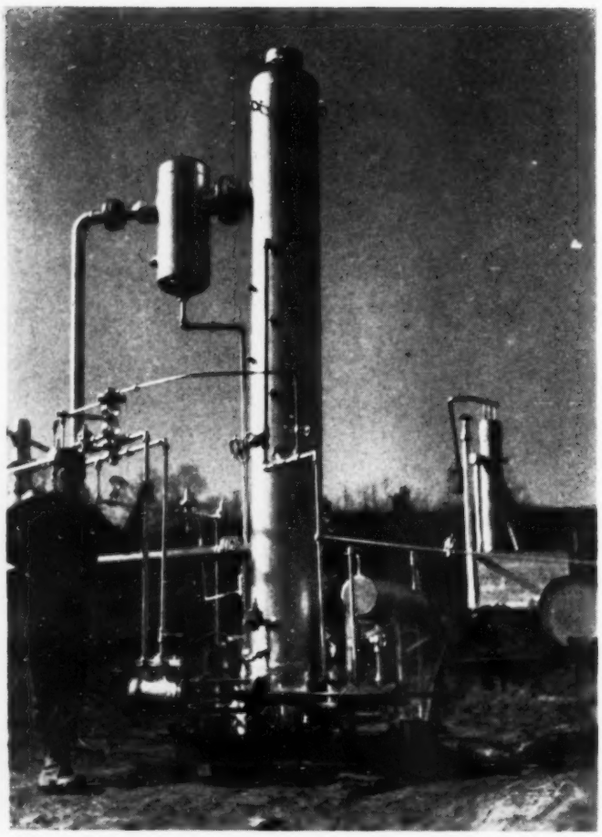

Individual well dehydration installation in West Virginia. This is a portable unit and as many as five have been manifolded to handle large gas volumes

High-pressure gas enters these heating units before beginning its course through the dehydration plant

investigators realized that the performance of a dehydration system, whether it be by solid adsorption or liquid absorption, depended upon both the dehumidifying agent and the equipment design. This resulted in several classes with variations of each. A late review of current information and data indicates that three systems or processes are now in general use. In describing these types or classes they do not lose their basic identity, but individual characteristics are noted. The principal difference is in the state of matter at which the absorbent or adsorbent, liquid or solid, exists.

Processes in Use

The three most widely recognized and accepted methods of drying gas are as follows:

1. Absorption
   a. by solids
   b. by liquids
2. Refrigeration
4. Adsorption

A survey of available information relative to the most applicable installation reveals a general opinion of agreement that physical conditions, individual to that particular case, will influence or determine type selection. The pioneer liquid absorption plants employing a hygroscopic contact solution have the features of much later units. The basic cycle was that of the well-known gasoline absorption plant principle. As dew-point depression is the objective, the effective minimum range of each method is of paramount importance. These are given for a condition of 500-lb. pressure and 70°F. contact temperature as: Cooling, 55°F.; calcium chloride solution, 40°F.; diethylene glycol, 20°F., and activated alumina, minus 70°F.

The drying agents listed, with a few experimental variations, were introduced to the industry in that progression. In the hygroscopic group can be placed calcium chloride, calcium chloride plus organics, glycerine, zinc chloride, and diethylene glycol.

Calcium chloride solutions are still used where dew-point depression will permit, the limit being approximately 25°F. The corrosive nature of this medium particularly when even traces of oxygen or hydrogen sulphide are present, is a determining factor in its application.

Calcium chloride when mixed with an organic material, such as glycerine or diethylene glycol, will permit a dew-point of 35°F. with 75° contact gas at 300-lb. pressure.[2] Glycerine has been tried but found unsatisfactory because partial oxidation resulted in a highly viscous state of liquid with less effective hygroscopic value. Zinc chloride has been used experimentally and produces depressions comparable with glycol, but its corrosive nature and cost discouraged general use.

Diethylene glycol has found widespread acceptance in the last five years as an absorbent when extremely low depressions were not necessary. During the intervening years operating experience in these plants has proved this material to have definite advantages as compared to other liquid agents. It has a 60° dew-point depression. It also has desirable physical properties, being noncorrosive, moderately viscous, and has slight lubricating properties, besides being chemically stable. The cost and

[2]Henry N. Wade, Parkhill-Wade, Inc., *Gas*, September, 1936.

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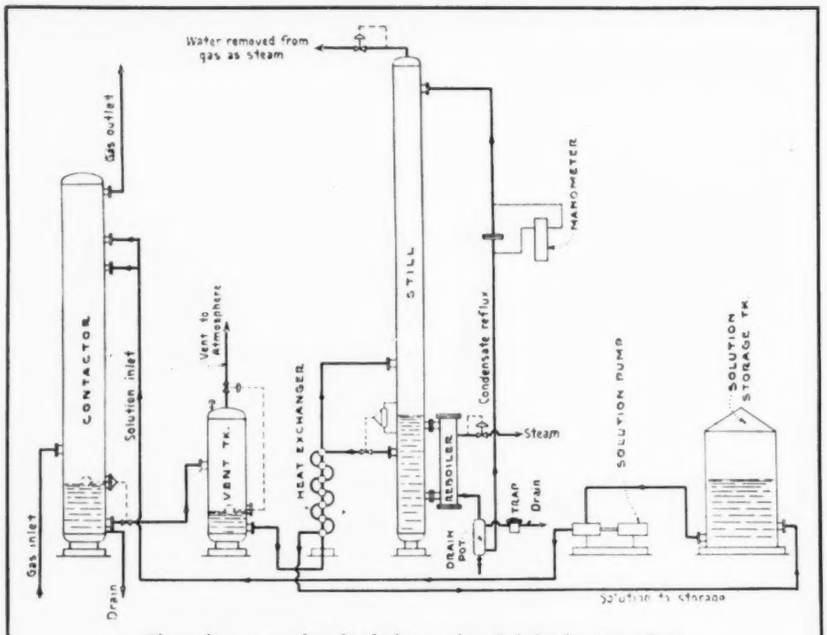


Flow diagram of a diethylene-glycol dehydration plant

availability at this time might be a disadvantage.

The relatively recent commercial production of solid granular adsorbents, coincident with abnormally higher gas pressure now used, has attracted the field operators to this type of dehydration. The solid-adsorbent type plant, using activated alumina, is necessary when substantially complete dehydration is required. Activated alumina is a granular, inert, porous solid capable of removing substantially 100 percent of the moisture from a gas until it has taken up 12 to 14 percent of its weight of water. The alumina is a bauxite product of which there are several grades. One deviation of pure alumina has the trade name "Florite" and is being used satisfactorily in adsorption plants at this writing.

Plant Design and Operation

In any dehydration system, whether it be solid adsorption or liquid absorption, there are two important items to consider. The first is the absorbent itself, and the second is the equipment employed. Both contribute to the performance, that is, the cost of removing a unit quantity of water. From available information regarding operating experiences of several types and combinations, it is apparent that satisfactory results are to be expected if preliminary engineering studies are made and their relation to the problem correctly applied. For the purpose of this article, the discussion of design and operation of plants will be primarily confined to the diethylene glycol absorption and alumina adsorption types. At present these are the accepted choice and current trade journal releases discuss their mechanical features and operating performances.

Different operating conditions on gas transmission systems obviously call for various plant design to meet those conditions successfully and economically. The following covers in some detail the more recent installations as reported.

Increased volumes and higher discharge pressures at the Sneed station[3] of the Panhandle Eastern Pipe Line Company accelerated hydrate composition, necessitating a dehydration plant. This plant is an excellent example of planned engineering and exacting construction. The plant consists primarily of three contactor-separator vessels, diethylene circulating pumps, a fractionating column, and the necessary control equipment for automatic operation. Steam is used for pump power and rectification of the lean glycol. The contactor-separators contain an internal baffle arrangement as might be found in a steam trap, and designed with a convex baffle at the top of the gas inlet. After gas-glycol contact the dry gas enters the transmission line and the lean glycol gravitates to the bottom where it flows into a float tank and is automatically pumped to a separator and vent tank. Here the gasoline and glycol-water mixture separates, the gasoline being drained off the surface and the water-glycol is forced to a rectifying column. These operations are controlled by motors actuated by float controls. When this water-glycol level is at its low point, automatic venting is provided. Before entering the rectifying column the water-glycol mixture is preheated in a bank of heat exchangers by hot glycol from the bottom of the column. The liquid enters the still and gravitates over bubble trays to the bottom where it is piped to a reboiler and heated to 270°F. to remove water and then re-enters the still.

This hot steam and glycol vapors ascend the tower from tray to tray through bubble caps. As they ascend, they are met by the downward flow of lean glycol. The glycol vapors tend to join the down-flowing liquid, and the water as steam tends to rise, thus effecting a concentration of glycol. To prevent glycol vapors from being carried away, water as a reflux is piped into the top tray, which maintains a temperature differential between top and bottom. As the reflux water descends, its temperature increases to a point where entrained water on the upward flow is evaporated, thus enriching the glycol. Steam-glycol vapors from the heat exchanger entering the still for the separation processes, bubble up through this reflux, and are fractionated in the same manner as the vapors ascending from the bottom. The enriched hot glycol is pumped through the heat exchanger in which the incoming water-laden glycol is preheated. From the exchanger, the enriched glycol enters a surge tank from which it is pumped to the top of the contactor to begin another circuit.

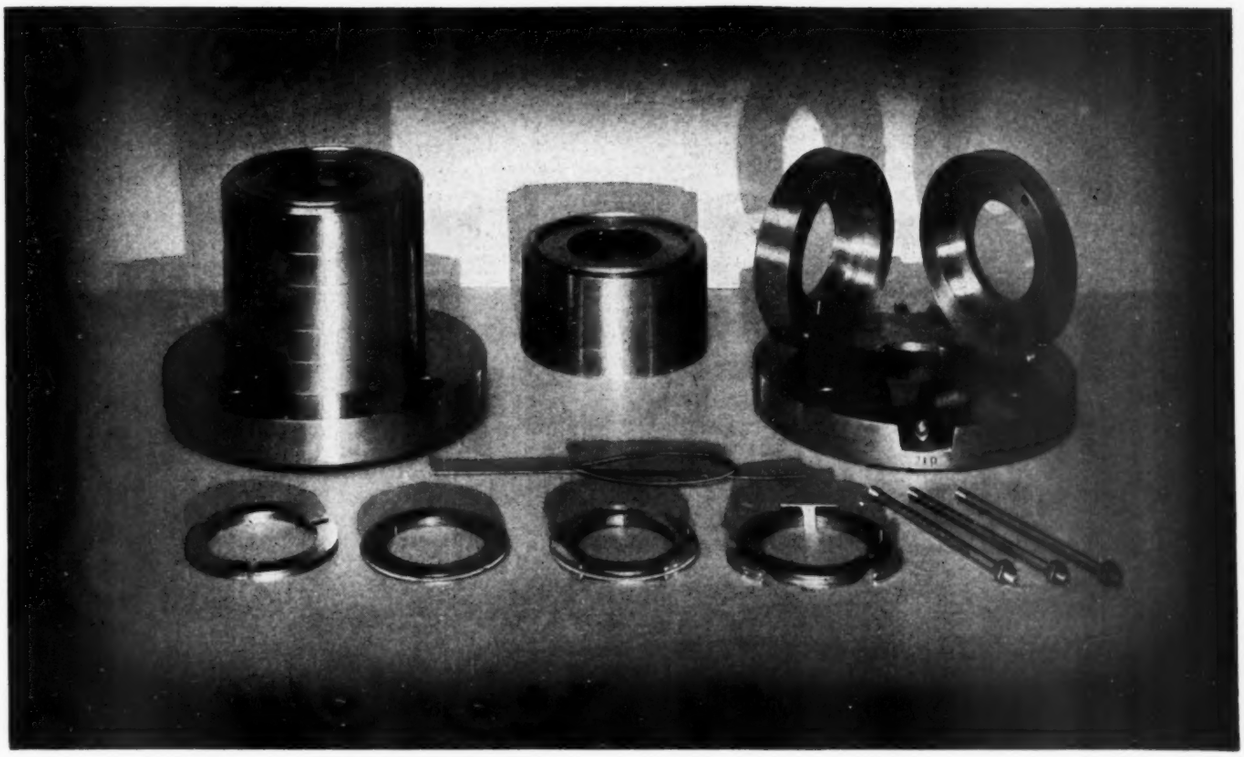
Glycol Plants

The United Gas Pipe Line Company recently installed three glycol plants on their Lirette-Gibson-Mobile transmission line project.[4] Two are 60,000,000 cu. ft., 750-lb. units and the other a 15,000,000 cu. ft. 500-lb. unit. Conditions necessitate a 15°F. outlet dew-point or a 55° depression from 70°F. gas. The plants are of the latest engineering design, equipped with full automatic flow control instruments. The same general design of contactors, stills, reboiler, exchanger, and surge tank constitutes the plant. Dowtherm vapor for heating the glycol is generated in small vertical boilers. There is no loss of glycol in these systems as they are completely closed. Before the plant was built at Lirette, it is reported that 300 to 500 gal. of water accumulated each day in a drip 30 miles downstream. No liquid has been recovered since drying began.

The chief variation in diethylene glycol plants now built is in the heating methods employed. These include ordinary small steam boilers, direct-fired heaters, and Dowtherm boiler installation.

[3]F. S. Young, *The Petroleum Engineer*, June, 1941.

[4]F. H. Love, *The Petroleum Engineer*, September, 1942.



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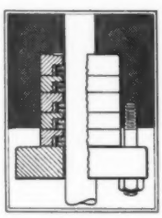

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Contactor tray design is important in glycol plants. This is particularly true if the gas flow rate through the plant is not regulated closely. Surges in gas flow causes the retained glycol in the bubble trays to be dumped into the lower section. As it is automatically pumped to the reconditioning still by float control, a constant flow through the still will not permit time for dehumidification. The reverse is true of abnormally low flow rates. The elapse of time between the transfer of contactor water-laden glycol to the still is of such duration that overheating occurs in the still by slow cycling.

Diethylene glycol at a quoted price of $1.50 per gal. sounds very expensive, however, it has been reported[5] from cost record kept that the glycol item is 0.003 gal. per 1,000,000 cu. ft. of gas conditioned or less than 5 cents per 1,000,000 cu. ft. of gas. Plant construction cost will average about $750.00 per 1,000,000 cu. ft. capacity. Capital charges, including taxes, insurance, interest on investment, depreciation, and maintenance is shown as $0.54 to $1.08 per 1,000,000 cu. ft., the actual cost being a function of the plant load factor. Labor cost per unit conditioned decreases as plant capacity increases. For a 60,000,000 cu. ft. plant the labor item will be about $0.30 per million. The elimination of high-pressure steam—use of gas-driven glycol pumps—automatic operating and safety controls and an effective minimum glycol rate all contribute to the economy of unit gas volume cost. Twenty-five gallons of circulated glycol per 1,000,000 cu. ft. of gas in a 4-tray contactor results in an effective dew-point with gases of less than 40 lb. of water per 1,000,000 cu. ft. This minimized glycol rate also reflects a cost reduction in pump cost, power, and initial investment in coolers, reboiler, and heat exchangers. The cost of gas conditioned in the modern plant is given as 4 to 6 mills per M. cu. ft.

[5]T. S. Bacon, *Gas Age*, May 21, 1942.

Solid Adsorption Plant

The solid adsorption type plant has received increasing consideration the last two years. Because of its relatively recent adoption, published information on operation is limited. There are sufficient data available, however, to establish this method as practical and economical, especially when transmission pressures exceed 750 lb.

The Southern Natural Gas Company[6] completed a 1200-lb. line last year and at such pressure dehydration of a wider dew-point range than usual was necessary, as the hydrate decomposition temperature is 67.1°F. The solid adsorbent type was chosen for the following reasons: (1) Greater dew-point depression, (2) continued availability of adsorbent material, (3) simplified process of reactivation, (4) absence of solidifications under higher pressures, (5) low operating cost, and (6) apparent freedom from entrained losses.

This plant consists of four absorber towers, set in batteries of two towers in parallel; a 104-hp. oil-field type boiler; one reactivation gas heater; two reactivation gas heat exchangers, and a condensate receiver. The absorbent towers have four trays spaced five apart to prevent packing of the material. Inlet and outlet gas connections are at the bottom. Inside the tower is an 8-in. elbow riser welded to the inlet and extending to the top. Through this the gas passes to the top of the tower, then downward through the drying agent where it enters the main gas line. This outlet dew-point averages minus 12°F. Two of the towers are charged with activated alumina and two with "Florite." Each tower has a 6500-lb. charge of the desiccant. The batteries are operated alternately in eight-hour cycles. One battery is being reactivated whereas the other is in service. Gas heated by steam to 380°F. passes to the lower part of the wet adsorber for five hours at approximately 200,000 cu. ft. per hour. At the end of this period the temperature at the tower top will have reached 325°F. at which point it is automatically shut off. This hot water-ladened gas is piped to heat exchangers where it is cooled to 60°F. At this temperature condensation results and the partially dehumidified gas enters the bottom of the active contactor for final drying.

[6]C. E. Terrell, *Gas Age*, June 4, 1942.

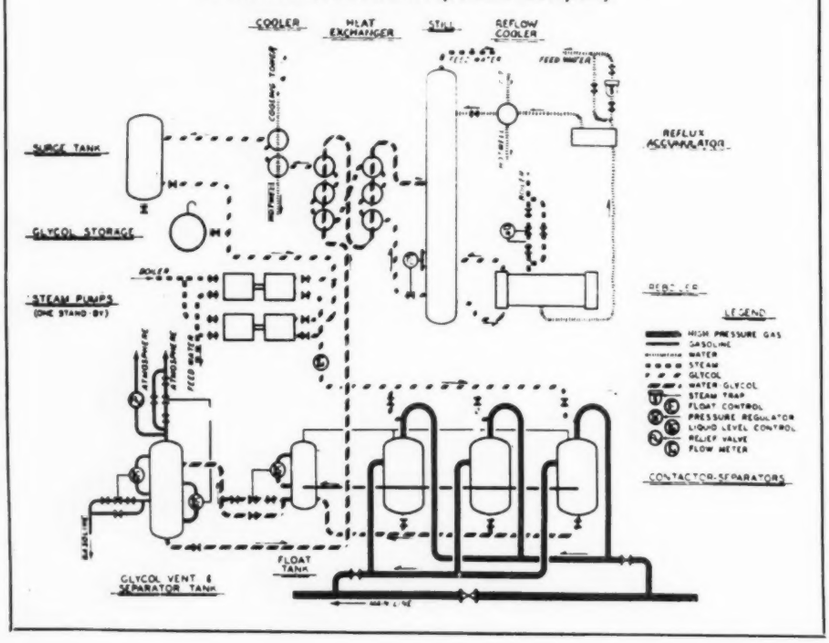
Experience[7] indicates the "Florite" may have a slightly greater affinity for hydrocarbon vapors and slightly less adsorptive properties for water vapor than the activated alumina. The alumina may be selective and have the faculty of more readily releasing what might be termed the super-saturation of hydrocarbons that takes place in both desiccants in the first hour or so of exposure to the gas flow and which are largely displaced by water vapor in the later hours of the cycle. Conclusive deductions relative to selectivity will probably be established from future plant operation.

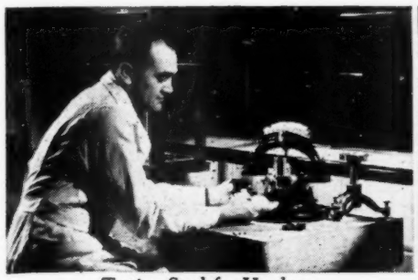
Recent flow tests indicate there is a greater pressure loss through the "Florite" than through the alumina. After a year's operation at the above described plant the original charges of desiccant appear to be as effective as at the beginning. The price of the "Florite" is approximately 7 cents per lb. and alumina is 24 cents per lb.

The Oklahoma Natural Gas Company is just completing a 60,000,000 cu. ft. per day solid adsorbing type plant near Chickasha, Oklahoma. This plant will handle gas taken from the cement field at 1800-lb. pressure and after dehydration will be transmitted through their line to Stroud, Oklahoma, where it enters the main transmission system. It is a two contactor tower plant, each charged with 8000 lb. of

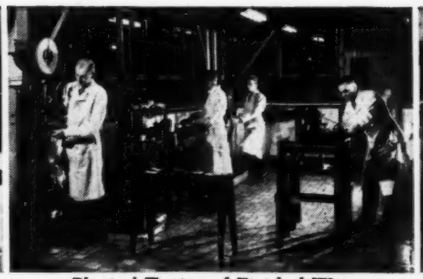
[7]C. E. Terrell, *Private Communication*, December, 1942.

Flow diagram of dehydration plant at Sneed Station of Panhandle Eastern Pipe Line Company





Testing Steel for Hardness



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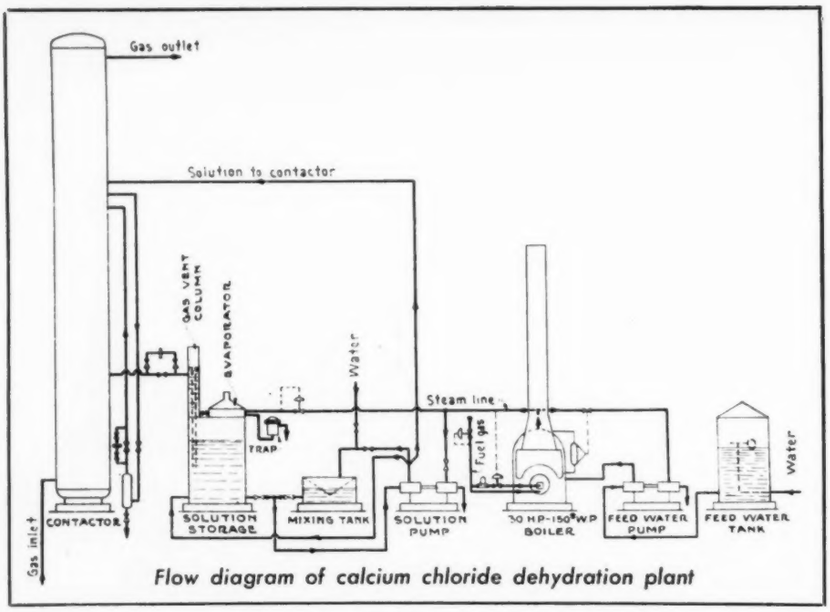

Flow diagram of calcium chloride dehydration plant

"Florite." The operating cycle is similar to that already described.

Technical Studies

It is evident that in the earlier stages of gas dehydration studies, the chief concern was with practical field difficulties and ways and means of overcoming them. It became apparent, however, that such work was somewhat retarded by the lack of more exacting basic information on the chemical and physical characteristics of these hydrates. These technical studies resulted in much valuable data that could be correlated with the mechanical program of progress, thereby effecting a better understanding of the entire picture.

The hydrate[8] characteristics of a number of natural gases have been determined dealing with pressure-temperature-composition behavior of various pure gaseous mixtures. No simple relationship was found that is positive evidence of the hydrate characteristic of a gas from its analysis. Ordinarily, however, it can be concluded that the higher the thermal value of a gas, the more readily it will form hydrates.

Further reports[9] have extended both the data and the theory of the gases. This information presents methods for predicting the temperature at a given pressure or vice versa, at which natural gases will form hydrates if saturated with water. Data are shown for methane-propane-water, methane-pentane-water, and methane-hexane-water systems in four-phase equilibrium. The data indicate that natural gas hydrates behave as a solid solution and that pentanes and heavier hydrocarbons do not enter into the solid phase. The equilibrium constants present data that permit approximations of conditions for hydrate formation, from composition of the gas.

Knowledge of the water content[10] of gas under pressure is of value to the gas engineer in the operation of gas systems and particularly in a study of gas dehydration. Experimental work with two natural gases, air and helium, shows that the water content of these saturated gases at pressures up to 600 lb. per sq. in. may be higher than the values calculated from vapor-pressure data using common gas laws. The water-carrying capacity of the natural gas studied was 30 to 35 percent greater than calculated values.

Technical data that permit the prediction of the temperature distribution[11] along a gas transmission line are of importance in determining the possibility of hydrate formation and quantity of water at various points in the line. By means of equations and a temperature-pressure-enthalpy chart it is possible to calculate how much gas must be heated to prevent trouble; amount of heat required; whether hydrates will form at a designated point, and amount of entrained water.

In conclusion, it can be said that although most of the types of dehydration plants have a basic operating cycle and similar units, they are designed for a given set of conditions. No doubt improvements will continue to appear both in design and in operation, as the equipment manufacturers, the research engineers, and technicians are continuing this work. This will probably result in even more streamlined installations.

The author wishes to express his gratitude to C. E. Terrell, Southern Natural Gas Company; Louis Weiss, Stearns-Roger Manufacturing Company, and E. J. McConnell and Frank Orelup, Oklahoma Natural Gas Company, for their interest and assistance in the preparation of this material.

[8]W. M. Deaton and E. M. Frost, *Gas*, June, 1940.
[9]D. L. Katz and D. B. Carson, *Gas Age*, February 26, 1942.
[10]W. M. Deaton and E. M. Frost, *American Gas Journal*, October, 1941.
[11]R. V. Dunkle, *Gas*, September, 1942.

☆ ☆ ☆

A single adsorber type dehydrating installation on a pressure-maintenance project. Activated alumina is the drying medium

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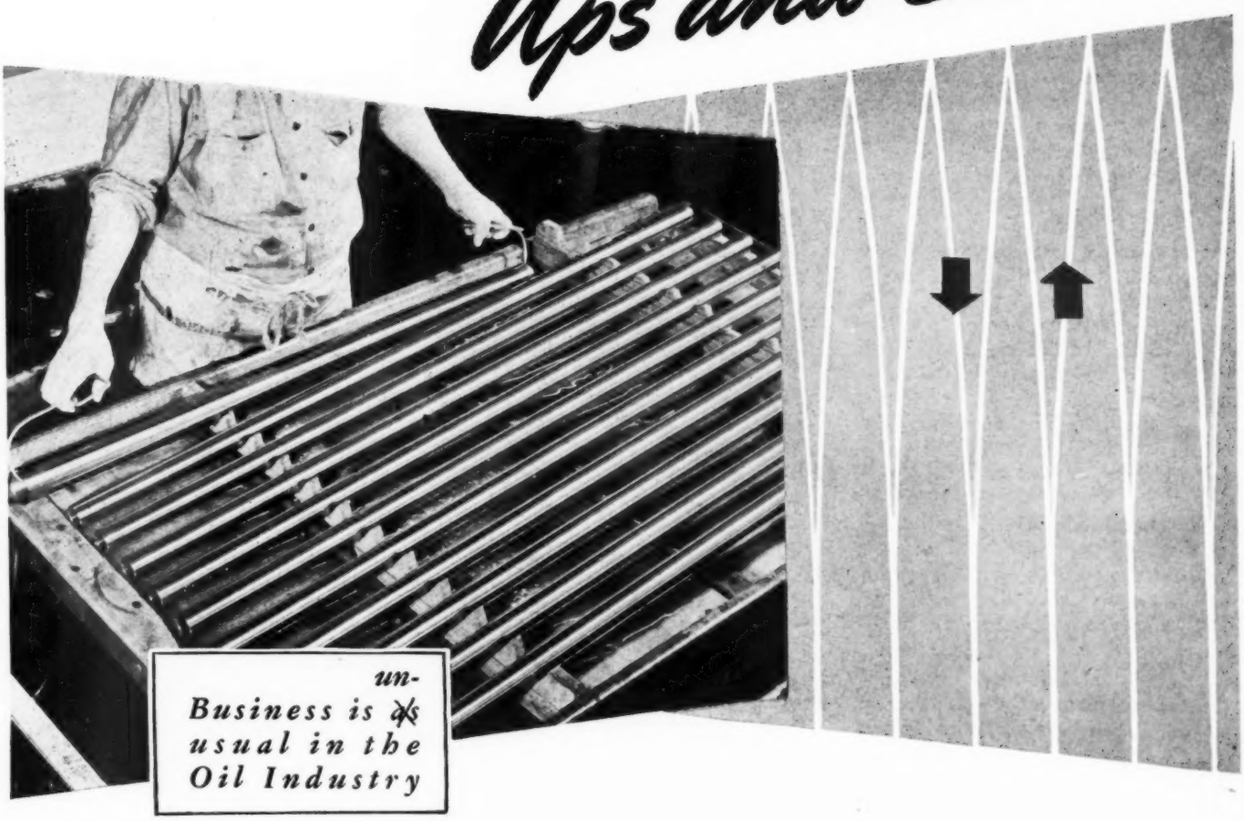

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P 537.
P 538.

Secondary Recovery May Have Vital Role In the War Effort

PETROLEUM ENGINEER Exclusive Feature

☆ **Decline in discovery of new fields enhances importance of secondary recovery methods to increase oil production**

by Paul D. Torrey
Consulting Engineer

AUTHORIZATION of a study of secondary recovery methods by the Topical Committee on Production Practice of the Division of Production, American Petroleum Institute at the Mid-Year Meeting held in Wichita, Kansas, May, 1938, did not result in those connected with the proposal foreseeing that the completion of certain phases of the work designated would come at a time when the combined impact of war conditions on the oil industry and a declining rate of discovery of new fields would make the application of secondary recovery methods for increasing production of oil of vital importance in several states. The general program of the Standing Subcommittee on Secondary Recovery Methods at the time of its organization was:

1. To demonstrate that the petroleum industry has not been unmindful of its obligation to conserve the available oil resources of the nation.

2. To assemble information and compile data on many existing secondary recovery operations in the United States.

3. To provide theoretical and practical information to serve as a guide for the efficient recovery of oil.

4. To develop interest in the preservation of marginal properties and fields, which otherwise might be abandoned unless some method for the stimulation of production were applied.

It was recognized at the beginning of the A.P.I. study that the application of secondary recovery methods constituted one very important phase of a national program for the conservation of oil. Such being the case, the work of the Subcommittee received instant and continued encouragement from Federal authorities and bureaus, from state regulatory bodies, and from the Interstate Oil Compact Commission. In course of time a continued increase in interest in the Subcommittee's work was manifest, as was reflected by the symposium on secondary recovery held by the Interstate Oil Compact Commission at Lexington, Kentucky, June 19 and 20, 1942, and by the contribution the Subcommittee was able to make at approximately the same time to the Oil Reserve Committee appointed by the Petroleum Industry War Council.

PAUL D. TORREY

is chairman of the Standing Subcommittee on Secondary Recovery Methods, American Petroleum Institute—Received the degree of B.S. in petroleum geology in 1925 from the University of Pittsburgh—Served for two years with the Oil and Gas Division, U.S.G.S., in Utah, Wyoming, Montana, Arkansas, and Pennsylvania —Spent a year with the Northwestern Pennsylvania Oil Producers Association as gelogist and petroleum engineer—In 1928 opened an office as consulting geologist and engineer specializing on secondary recovery methods in eastern gas fields—In 1935 joined Sloan and Zook Company as geologist in charge of exploration work in the Texas Gulf Coast and Louisiana—Later entered consulting work, making his headquarters in Houston, Texas.

The publication by the American Petroleum Institute of *Secondary Recovery of Oil in the United States,* during November, 1942, served further to focus attention on the increased possibilities of application of secondary recovery methods. Coming at a time when expanded production, particularly in many of the older, Eastern fields, is being encouraged by the Office of the Petroleum Administrator, the opportune nature of the publication of this book should be quite evident.

It may be stated with little fear of contradiction that the application of secondary methods has served in the past to produce oil that otherwise would be unobtainable and has perpetuated the oil business in a number of fields. At present, during a period of national emergency, the same methods, proved by years of successful, practical experience, may be employed to provide oil expeditiously that is sorely needed for defense purposes. The writer firmly believes that the proper application of secondary recovery methods can serve to stimulate production of needed crudes in certain fields where the scarcity of materials or existing well-spacing regulations preclude extensive new development to increase primary production.

Secondary Reserves of Oil

Any consideration of the amount of oil available in the United States by the application of secondary recovery methods properly must take into account the fact that large reserves are known that cannot be produced profitably under existing price schedules. Furthermore, it should be emphasized that the accompanying tabulation (Table 1) of secondary reserves should not be confused with the annual reserve estimates prepared by a specially designated A.P.I. committee. The proved secondary reserves herein listed, taken from page 11 of "Secondary Recovery of Oil in the United States," comprise oil in fields essentially depleted by primary production methods that can be produced profitably at present by secondary methods. The semi-proved and marginal reserves represent oil in known reservoirs, which competent engineering analysis indicates should be adaptable to secondary recovery operations, but which because of low possible recovery or high development cost cannot be regarded as being immediately available.

Since the compilation of Table 1, reliable information has been developed that justifies an increase in the estimation of the semi-proved and marginal reserves by approximately 1,000,000,000 bbl. This increased reserve exists in Pennsylvania, Kansas, Oklahoma, and

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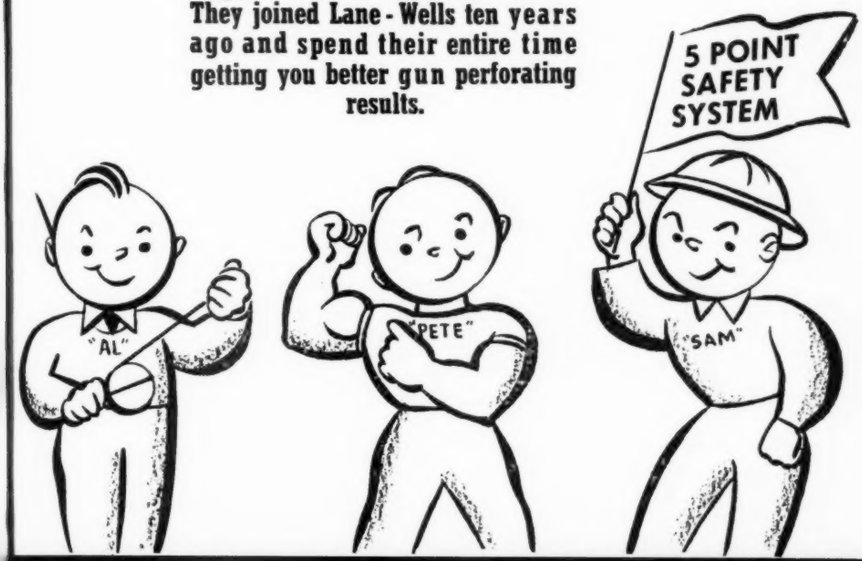

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California. Therefore, it now appears reasonably safe to predict that the possible secondary reserve in the United States amounts to about 4,500,000,000 bbl. This figure represents an increase in the now known petroleum reserves of the country by about 20 percent.

Attention is called to the fact that this substantial addition to the proved reserves of the United States constitutes oil for which no costly or hazardous exploration program is required. The increased reserve occurs in known reservoirs in which secondary recovery methods are being applied or in which engineering investigation indicates a high probability of successful application.

Although, obviously, it would not be practicable to produce the secondary reserves at a rate sufficient to meet the entire national requirement, it is a matter of great significance that these reserves are equivalent to an average daily oil production of 4,000,000 bbl. for a period of slightly more than three years. The hope can be expressed that the increase in the Nation's oil reserves, brought about solely by the proved application of secondary recovery methods, will be adequate to supply much of the oil required for the victory of the United States and its Allies. Should such be the case, at the end of hostilities, the reserves of oil available to supply the normal, peace-time requirements of our people should not be diminished materially from the present known primary reserve.

It should, of course, be appreciated that the accuracy of estimation of secondary recovery reserves is more reliable in states where these methods have been applied extensively, and where actual operating experience has been combined with scientific investigations to provide a sound basis for the development of reserve calculations. These conditions exist with greater frequency in the older oil fields of the Eastern States, although great progress has been made in the last five years in the Mid-Continent and Southwestern States. It is indeed a fortunate coincidence, however, that the large, proved secondary reserves of the Pennsylvania Grade Crude Oil Area are situated in such close proximity to the areas where oil is presently needed so desperately both for the use of the armed forces of the United States and for essential civilian consumption. If the present production of Pennsylvania Grade Crude Oil, which comes largely from secondary recovery operations, were not now available the lack of this certain source of supply might have very critical aspects. The contribution to the war effort now being made by the progressive operators in the Eastern States must be recognized as an important partial source of relief from an acknowledged difficult situation in the distribution of petroleum products.

TABLE 1

Estimated secondary oil reserves in the United States

(In most cases as of January 1, 1942)
Millions of barrels

State	Proved reserves	Semi-proved and marginal reserves	Total estimated reserves
New York	107	123	230
Pennsylvania	425	154*	579
West Virginia	147	170	317
Ohio	20	40	60
Kentucky	39	31	70
Illinois	18	208	226
Kansas	228	†	228
Oklahoma	249	270‡	519
Louisiana	36	107	143
Texas	59	911*	970
Rocky Mountain States	27	§	27
Total	1,355	2,014	3,369

*This figure includes only marginal reserves. Additional semi-proved and physically recoverable reserves in Pennsylvania have been estimated variously as high as 879,000,000 bbl.

†Unknown, but probably of large magnitude.

‡An additional physically recoverable reserve of 200 to 400 million bbl. in certain fields has been estimated by competent authorities obtainable at a substantially increased price.

*This figure does not include indicated results from salt-water injection in the East Texas field.

§Unknown, but probably of small size, and not in excess of estimated proved secondary reserves.

Status of Operations

The importance of secondary recovery operations in the production of oil is more apparent in certain of the Eastern States than elsewhere. This may be demonstrated most impressively by citing an increase in production in New York of 600 percent since 1912 and an increase in production from the Pennsylvania part of the Bradford field of 800 percent since 1912. These substantial gains may be attributed directly to the application of secondary recovery methods.

A summary of some statistics relating to the magnitude of secondary recovery operations in the United States, as compiled by the A.P.I.'s Standing Subcommittee on Secondary Recovery Methods, reveals that a minimum of 306,282 acres of oil productive territory was affected on which there are some 50,636 producing wells and 34,956 injection wells. These comprise some 1236 different projects in 254 separate fields with an estimated plant investment of $281,496,000. The value of secondary recovery oil produced in the United States during 1942 is estimated to be $84,000,000.

The influence of secondary recovery operations on total production in Kansas and Oklahoma is becoming of greater prominence, as both water-flooding and systematic gas repressuring projects, initiated several years ago, are beginning to reach the peak stages of production. The successful results obtained in many of these projects cannot fail to encourage further expansion of secondary development. There can be little doubt that the production from secondary recovery operations in these states will have a stabilizing effect and will serve to reduce the rate of decline that can be expected from the primary production.

Secondary recovery operations in the great productive areas of the southwestern states are not nearly so important in relation to total oil production as they are in the Eastern and Mid-Continent areas, although there are more gas repressuring projects in Texas than in any other state. In both Texas and Louisiana, moderate secondary recovery programs are serving to maintain many old fields in profitable operation and thereby are preserving important reserves of oil that otherwise might be lost if the fields were abandoned.

Production Aspects

A most attractive feature of many secondary recovery operations, both from the standpoint of rate of return of invested capital and as a contribution to the immediate development of production needed for the war effort, is the rapidity with which materially increased production many times can be obtained.

The rate at which oil is produced by water-flooding has been established by the results of operations over a period of more than 20 years. In the Bradford field and in the Mid-Continent area it has been shown that the percentages, given in Table 2, of the total recovery from average intensive water-flooding operations may be expected annually.

It will be noted from Table 2 that

TABLE 2

Annual percentage of total recovery obtained from average intensive water-flooding operations

Year of average productive life	Bradford		Southeast Kansas and Northeast Oklahoma	
	Annual percentage	Cumulative percentage	Annual percentage	Cumulative percentage
First	17	17	22	22
Second	36	53	33	55
Third	19	72	21	76
Fourth	10	82	13	89
Fifth	6	88	7	96
Sixth	4	92	4	100
Seventh	3	95	..	..
Eighth	2	97	..	..
Ninth	2	99	..	..
Tenth	1	100	..	..

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more than one-half of the total recovery from water-flooding can be expected during the first two years of operation. Thus, under normal conditions, the entire development cost should be liquidated during this period, a very considerable item in the financing of a project. The production that can be obtained profitably during the latter life of a water-flooding operation depends largely upon its size and the number of wells involved. In a large project the per-barrel cost of operation, during the final stages of depletion, may be sufficiently low to permit production to be continued for a sufficient period to obtain maximum recovery. In smaller projects, this is rarely possible.

Dickey and Bossler, in their chapter on "Oil Recovery by Air and Gas Repressuring in Pennsylvania," (Chapter No. 9 of *Secondary Recovery of Oil in the United States*), have pointed out that the production from air and gas repressuring operations, if unaffected by new wells or mechanical changes in operation, approximates in rate of decline the familiar hyperbolic curve that characterizes the primary production of oil under internal gas drive. This statement has been confirmed by studies of production curves from air and gas repressuring projects in almost every oil-producing state of the country. As reservoir, injection, and production conditions are by no means constant throughout the United States, annual percentages of total recovery for air and gas repressuring, such as those presented in Table 2 for water-flooding operations, are so divergent as to be misleading unless applied with full knowledge of all geologic and production factors involved. Once a trend of decline has been established, in air and gas repressuring projects, however, a projection of the curve on logarithmic paper will permit a reasonably accurate prediction of future production.

The effectiveness of secondary recovery operations in increasing the recovery of oil is illustrated in Table 3, which gives a summary of the results obtained in three typical water-flooding projects.

It is notable that secondary recovery operations have produced more than twice as much oil as the primary production in the Allegany field project. In the Bradford field the secondary recovery is almost twice that of the primary recovery. In the Nowata field project the secondary recovery has already produced more oil than was obtained by primary production, and it is estimated that at least 2000 bbl. additional oil per acre will be recovered before this project is depleted. Of great significance is the fact that the secondary recovery is being obtained in about 13 to 20 percent of the time required to obtain the lesser primary production. These figures are taken from operations in fields adapted to secondary recovery operations, and they should not be regarded as being applicable to all older productive territories. They do, however, support the contention that substantial quantities of oil needed for the accomplishment of the war effort may be obtained in certain fields at a rate that may help materially to relieve existing shortages.

Factors Affecting Development

The history of the development of secondary recovery operations in the United States has been reviewed by the writer in Chapter 2 (pages 18-20) of the A.P.I. book on *Secondary Recovery of Oil in the United States*. For the purpost of this article it will suffice to state that the original discovery of the beneficial effects of secondary recovery methods in the Eastern States was largely accidental. Their subsequent, more widespread application cannot be attributed to any sense of direct responsibility for conservation on the part of the operators. Confronted, as they were, with declining production, which could not be stimulated profitably by an increase in primary well density, or by depressed crude oil prices brought about by the discovery of new, prolific, competitive fields, the operators in the older productive territories were faced with the problem of increasing production to the extent that it would at least equal the cost or go out of business. This condition was maintained up until the time when it became apparent in the Bradford field, beginning about 1920, that secondary recovery operations could be developed as a separate and in some respects a highly specialized part of the oil business.

In recent years, since the application of secondary recovery methods has been established as an important potential source of crude supply, it is rare that a shallow producing area is abandoned without an investigation of its secondary recovery possibilities.

The controlling factor in all secondary recovery operations is, of course, the relation between oil recovery and cost of development. Closely related thereto is the desirability and price paid for the crude and to a lesser extent the accessibility of the field to markets for refined products. The chief retarding reason for a much wider expansion of secondary recovery operations is the price paid for crude oil. A higher crude oil price will permit the development of lower recovery and deeper fields that would not be profitable under existing conditions. Admittedly, a general advance in crude oil price would also be an incentive for the discovery of new fields, but the outstanding difference between the discovery of new primary production and the development of secondary production is that the cost of exploration and the hazards connected therewith, major items in primary recovery operations, are relatively minor items in secondary recovery work. The fields where secondary recovery methods may be applied successfully are known fields whose productive limits, in most cases, have been defined years ago. A study of the geology and past productive history of the field combined with analyses of cores and comparatively inexpensive field tests can show, with a small degree of error, how adaptable the field may be to secondary recovery operations. Thus, it is self-evident that large quantities of oil can be made available without the ordinary hazards of exploration, if only an incentive in the form of an advanced price structure is granted.

The present situation in the Pennsylvania Grade Crude Oil Area may be cited to illustrate the pressing need for an increase in the price of crude oil. Secondary recovery methods were first developed in this area, and practically every important improvement in the technique of secondary production was there discovered. The operators have been most progressive in fostering research, both independently and as common enterprises, that has resulted in

TABLE 3

Results obtained from three typical water-flooding projects

Field	Allegany	Bradford	Nowata
State	New York	Pennsylvania	Oklahoma
Producing sand	Richburg	Bradford	Bartlesville
Average pay thickness, ft	40	61	52
Area affected, acres	83	322	80
Primary recovery, bbl. per acre	3,400	4,400	5,100
Secondary recovery, bbl. per acre	7,100	8,500	6,700*
Primary well density per acre	1/3.2	1/4.4	1/10.0
Secondary well density per acre	1/1.2	1/1.4	1/1.9
Primary recovery period, years	50	62	28
Secondary recovery period, years	7	8	6
Residual oil after end of primary recovery period, bbl. per acre	16,200	23,540	20,500
Percentage recovery by flooding	43.8	36.1	32.7
Average injection pressure†	2,100	1,900	1,600

*Flood not depleted 12/23/42.

†Top hole pressure lb. per sq. in.

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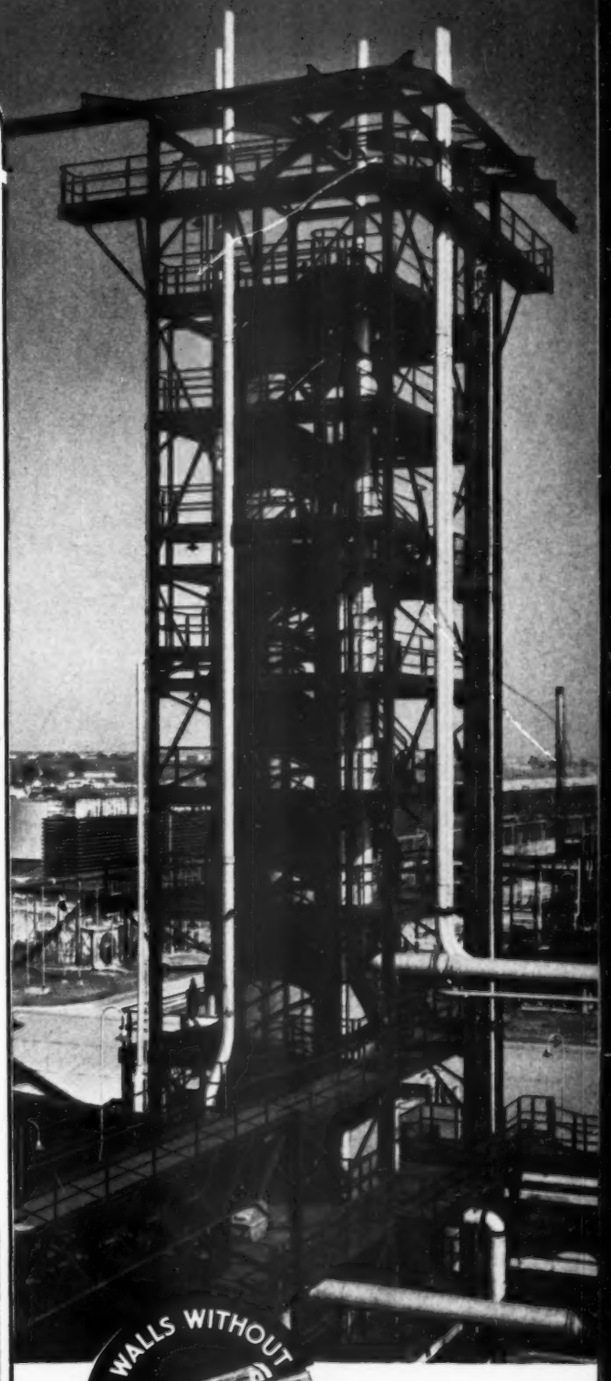

21 ANALYSES TO CHOOSE FROM *

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LOW CARBON, ½ MOLY.	2½ CR., 1 MOLY.	7 CR., ½ MOLY.
LOW CARBON, 1 MOLY.	2½ CR., ½ MOLY., ¾ SIL.	8 CR., 1 MOLY.
1¼ CR., ½ MOLY.	3 CR., ½ MOLY., 1½ SIL.	17 CR.
1¾ CR., ⅝ MOLY., ¾ SIL. (Resin Alloy)	3 CR., 1 MOLY.	18-8
2 CR., ½ MOLY.	5 CR., ½ MOLY.	18-8, TITANIUM
	5 CR., ½ MOLY., 1½ SIL.	18-8, COLUMBIUM
	5 CR., ½ MOLY., TITANIUM	

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notable increases in recovery efficiency and has demonstrated the possibilities for the further expansion of secondary recovery operations in other regions. Having already established the best methods and the results that may be anticipated, the only thing now needed in the Pennsylvania Grade Crude Oil Area to provide an increment of needed petroleum expeditiously is a price for oil concomitant with the extraordinary costs involved in the development of deeper and what must now be considered to be marginal fields.

The United States needs oil abundantly and at strategic geographic locations even more than it needs a multitude of other natural resources. Right at the back door of the most pressing demand exists large reserves whose availability in greater quantity would assist materially to alleviate the existing diminished supply. If the same sympathetic attitude taken toward the artificial maintenance of price for silver—a metal useful in certain arts and industries but found in other parts of the world in such abundance that the potential supply is far in excess of the demand—could be applied to the manifold problems of the petroleum industry in the Eastern States, great progress undoubtedly would be made to insure the certainty of additional oil production.

Adaptability of Fields to Secondary Recovery

No one should be misled by the thought that all oil fields, when depleted by primary recovery methods, are susceptible to successful secondary recovery operations. This was shown by developments in northeastern Oklahoma shortly after the first systematic waterflooding projects in the Nowata field began to make evident that substantial increases in production would be attained. Several ill-advised floods were begun shortly thereafter that were as outstanding failures as their predecessors had been successes. The reason for these failures can be attributed directly to low residual oil saturation. Had the operators taken the trouble to have investigated more closely reservoir conditions before beginning development, considerable losses would have been avoided.

Many of the criteria controlling the success of secondary recovery operations are discussed in *Secondary Recovery of Oil in the United States*. Reference is made to this book for more complete details. It can be noted here, however, that the most successful secondary recovery operations are found in fields where the primary production has been obtained by internal gas drive and where reservoir energy has been wastefully dissipated leaving a high residual oil content. It is doubtful whether sufficient oil will be left in fields that have benefited from uniform, natural water-drive to justify secondary recovery operations. If water encroachment has been unequal in the various beds of the reservoir, however, resulting in the trapping of considerable oil in zones of relatively low permeability, undoubtedly, opportunities for secondary recovery will exist.

The physical properties of oil reservoirs that control the success of secondary recovery methods have been described adequately by various writers. A repetition of this information is needless. It may be emphasized, however, that although uniformity of the reservoir is most desirable, improved methods are now in the course of being developed to combat bypassing, which should shortly be available for general use. The successful control of bypassing through zones of higher permeability will improve materially the secondary recovery prospects of many fields.

If oil fields in the past had been produced with due regard to efficient reservoir performance there would likely be little present secondary recovery activity. Therefore, secondary recovery may be regarded as a correction of past mistakes. With the realization that mistakes have been made in oil-field development and operation, their avoidance in the future should receive greater emphasis. In this the application of methods of primary pressure control should occupy an important part.

Future of Secondary Recovery

As emphasized in a preceding section, the expansion of secondary recovery operations in several large areas in the United States is dependent upon the procurement of more favorable price schedules. Although the question of price is an essential factor immediately in every secondary recovery operation, it is possible to foresee that a point will be reached eventually where synthetic fuels and shale oil may be produced more cheaply than the development and operating costs of secondary recovery operations in deep fields. When this point is reached, however, a condition of rapidly approaching depletion of primary oil reserves, undoubtedly, will exist.

The emphasis now being placed on the production of certain special types of crude oil, needed for the war effort, may encourage rapid secondary expansion in fields where oil of the desired grade is known to occur. Obviously, it may be much easier to develop additional production by secondary recovery methods than it would be to attempt to discover new fields with no positive assurance that should these be found the oil would be of the quality required to meet the particular demand.

The work of the Interstate Oil Compact Commission in encouraging uniform legislation permitting secondary recovery operations is commended highly. In certain states, the introduction of water into an oil-bearing formation for the purpose of increasing oil recovery is in violation of existing statutes. The evidence showing the beneficial effects of secondary recovery operations is so impressive that it should not be difficult to convince state authorities that legislation clarifying existing laws or new statutes specifically permitting and properly controlling secondary recovery operations should be most desirable.

In the southwestern states, where the productive capacity of many fields is greatly in excess of the immediate demand for oil, the application of secondary recovery methods should find continued usefulness in the preservation of older fields now reaching the economic limits of primary production. If fields in this stage of depletion can be maintained in reasonably profitable operation by moderate secondary recovery programs, large reserves of oil will be preserved in a condition whereby they can be made available on short notice at some future time when the oil may be needed much more than it is at present. If fields that have reached the stripper-well classification of production are abandoned permanently, it is possible that the potential secondary recovery may not be sufficient to warrant redrilling of new wells. Therefore, the abandonment of such a field might result in a total loss of a very considerable oil reserve. The experience gained in preliminary secondary recovery operations designed principally for the preservation of an oil field should provide a valuable guide for more intensive future development.

It is reasonable to expect continued secondary recovery activity in many shallow producing areas for many years to come. The expansion of secondary operations in the near future to deep and marginal areas will depend largely on the scarcity of oil, which in turn will probably be controlled by the results obtained from the exploration for new fields. Should the rate of discovery of new fields continue to lag it will enhance the value of existing and lead to a more widespread application of secondary recovery methods.

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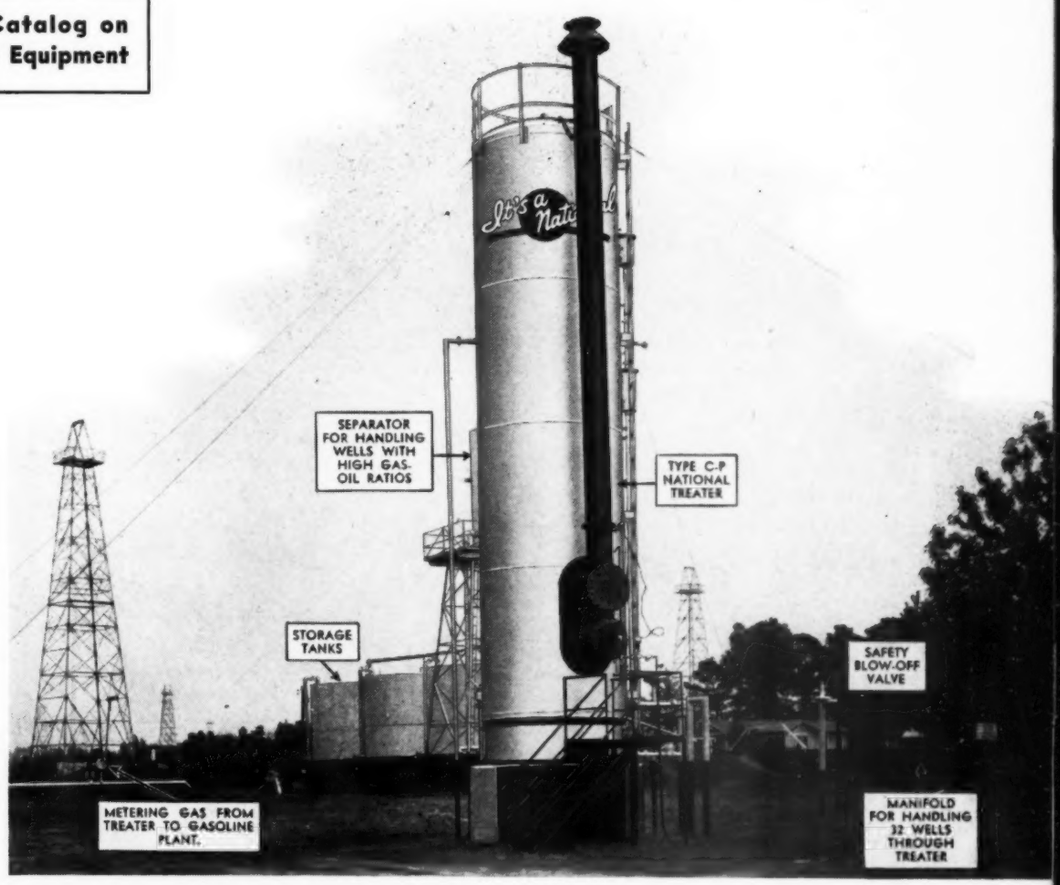
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Applying Engineering Methods To Pumping Wells

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☆ Study of individual well problems and correct application of engineering principles pays large dividends

by A. S. Ross

Petroleum Engineer, The Texas Company

UNTIL the last few years the amount of engineering applied to the operation of pumping wells was limited. This was especially true in the older fields where production declined to the point that additional investments for new equipment were difficult to justify, and standard operating practices had been developed through years of experience and hard work. Changes have come slowly by the trial and error method and by the improvements of equipment manufacturers; for it was believed that "barrels in the tank" was the main criterion of successful operation. It is now realized, however, that the careful study of individual well problem and the correct application of engineering principles will yield large dividends in the form of increased efficiencies, longer life of equipment, greater ultimate recoveries, decreased operating troubles, and lower lifting costs. It is the purpose of this article to show some of the fundamental methods that may be used and changes that may be made to produce these results with a minimum expenditure of time and money. It should be pointed out that any small improvement that results in the lengthening of time between servicing jobs or the reduction of repair work may mean a saving of thousands of dollars over a period of a year.

Speed of Operation

One of the most basic and important features of a pumping well is its speed of operation. This factor affects the peak load and the distribution of power throughout the stroke cycle. For example, on one well pumping with a standard rig at Smackover, Arkansas, dynamometer tests showed that by increasing the speed from 29 to 32 s.p.m. the peak load was decreased 1250 lb., with a small increase in polished rod hp. and a corresponding increase in production. The shape of the two cards is shown in Fig. 1.

It will be noted that the sharp stress reversals are eliminated at the higher speed. Also, it has been found that small changes in speed have produced great reductions in sucker rod breaks and tubing failures. As shown by Fig. 2 a standard rig running at 29 s.p.m. had been averaging one rod break per week. When the speed was slowed to 27 s.p.m., a bad reversal was removed and the same string of rods averaged one break per month.

A. S. ROSS

graduated from the University of Texas in 1937 with a bachelor of science degree in petroleum engineering—Since graduating he has been employed in the Louisiana-Arkansas Division of The Texas Company—His work has consisted of general engineering work in both drilling and production, and for the last 1½ years he has been working on a special assignment covering the application of engine ring principles to pumping wells—Is a junior member of A.I.M.E.

The problem is, therefore, one of determining the speed that produces the best harmonic motion in the rod string. This may be done very simply by use of Slonneger's formula:

$$\text{Frequency} = \frac{237000}{\text{Depth, ft.}}$$

Thus, for a 6000-ft. well,

$$\text{Frequency} = \frac{237000}{6000} = 39.5$$

From this frequency of 39.5 it may be shown that pumping speeds of an uneven or half order; such as $\frac{39.5}{3.5} =$ 11.3 s.p.m.; $\frac{39.5}{2.5} = 15.8$ s.p.m.; and $\frac{39.5}{1.5} = 26$ s.p.m., produce the most harmonious or efficient motion in the rod string. As the 3.5 order speed is too slow and the 1.5 order speed too fast, pumping speeds of 15 to 16 s.p.m. would produce the most desirable results. Following up this line of reasoning a group of wells pumping from 6000 ft., which had given considerable trouble due to tubing breaks, was studied to determine the source of the failures. It was found that all breaks had occurred on wells pumping at 18, 19, or 20 s.p.m. When these wells were slowed to 16 s.p.m. the trouble was eliminated and no more breaks have occurred. Production was maintained by lengthening the stroke or enlarging the pump diameter, when necessary.

Having established the proper pumping speed, the length of stroke and pump diameter should be chosen to obtain the desired production. The above formula and method have been found to give good results in wells below 3000 ft.; but they should be checked with a dynamometer when possible, especially on shallower wells.

Field studies have shown that dynamometer tests are of actual value, mainly as a basis of comparison between the conditions in a well before and after a change in operation is made. Certain characteristics can be detected from the shape or general appearance of the card, however. The examples in Fig. 3 show a few typical cases.

Selection of Pump

The selection of the correct pump is of great importance in the well setting, and particularly the size pump to be used. As the pump bore determines the weight of the fluid column, the smallest pump that will handle the desired volume should be chosen. This is especially true when the volume of fluid entering the well bore is limited. If the displacement is greater than the available fluid volume, a fluid pound will

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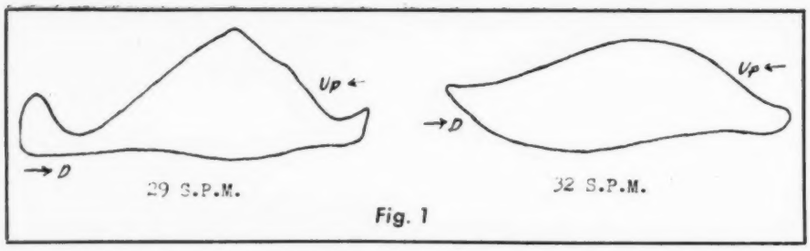


Fig. 1

occur and excessive well trouble will result in pump wear, rod and tubing wear, and rod fatigue. It is generally thought that more rod breaks are due to buckling on the down stroke than to any other cause.

Although it is difficult to select accurately the correct type pump for any particular well condition, certain generalizations may be made that are of aid in the selection of a pump. In general an insert pump is better because the entire pump can be pulled and repaired without pulling the tubing. It is also thought that metal-to-metal pumps are more satisfactory for deep wells because they require less servicing. This type pump, however, should be used only in wells making sufficient oil to give good lubrication. When trouble is encountered due to the formation of "gyp" in the pump, a metal-to-metal pump designed so that the plunger will stroke out both ends of the barrel will usually give the best service. When rings are used, either in a working barrel or an insert pump, longer runs will be obtained if the rings are pre-swollen to the correct size by soaking them for 2 or 3 days in light lubricating oil(mixed with kerosine if necessary). For pumping wells that produce fluid with a high sand content, the fluid pack type pump has been found satisfactory. If a plunger pump is used, however, a top hold-down should be installed so that there will be a minimum space for sand to accumulate that might stick the pump. On installations of small pumps in large tubing, a rod guide of approximately the same diameter as the tubing I.D. should be placed immediately above the pump to give proper alignment. In considering all factors pertaining to pump selection, the pump size is considered of greatest importance.

Valve Action and Service

In fields producing fluid with a floating sand it will be found that the ball and seat or pump valve failures account for a large percentage of the well trouble. These failures can be divided into two classifications: Those due to a distortion of the seat so that it is no longer perfectly round and those due to a breakdown or fatigue of the metal in the seat. A distorted seat will prevent the ball from seating perfectly and the fluid slipping through will cut a notch or groove in the seat. The fatiguing action occurs when the heavier mass of metal in the ball pounds the seat sufficiently hard to break down the structure of the metal so that a series of cracks will be seen around the seat. Both troubles can be greatly reduced by use of a seat that is sufficiently heavy and contains enough metal to prevent distortion or fatigue from the hammering action of the ball.

Service of Rods and Tubing

Another factor in the study of the pump action is the actual pump stroke obtained at the bottom of the well. This factor may be calculated with reasonable accuracy by Rieniet's formula or by the newer formula proposed by Dralle and Lamberger:

Rieniet's formula:

$$S_p = \frac{Q_B}{K} + S_s (\cos \Theta) - 2\frac{W_f}{K}$$

Dralle and Lamberger formula:

$$EPS = \frac{S}{\cos (0.0004\ LN)^0} - \frac{W_{oD} L}{2(10)^6}\left(\frac{1}{A_R} + \frac{1}{A_T}\right)$$

Where:

EPS = Effective plunger stroke, in.,
S = polished rod stroke, in.,

$$\text{Cos}\ (0.0004\ LN)^\circ = 1 - \frac{X^2}{2} + \frac{X^4}{24}, \text{ and,}$$

$$X = \frac{0.0004\ LN}{57.3}$$

L = length rods, ft.,
N = strokes per minute,
A_R and A_T = cross-sectional area of rods and tubing, sq. in., and
W_{oD} = Differential fluid load, (wt. of net fluid head on the full area of plunger), lb.

A simple empirical formula that may be used as a rule of thumb has been derived by Slonneger as follows:

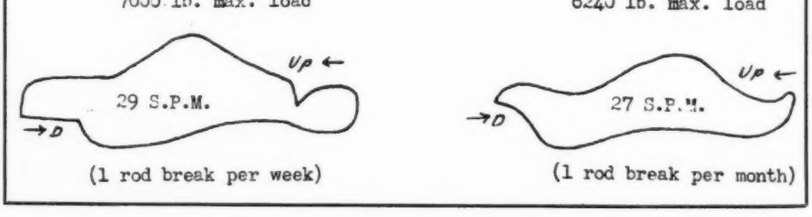
$$\text{Stretch in in.} = \frac{\text{depth (ft.)} \times \text{stroke, in.} \times \text{s.p.m.}}{303{,}000}$$

This formula, although not always applicable, may be used for medium depth wells when a normal pump and rod size are used and at pumping speeds of 20 s.p.m. or higher.

Crooked holes are a frequent source of trouble in pumping; however, worn rods and split tubing may occur as a result of tight plungers, fluid pounding, or fast pumping that causes slack or whip in the rod string on the down stroke. In preventing rod and tubing wear it has been found that soft metal rod guides placed at the crooked points give the most protection. For heavy wells in which the rod loads are too great for the soft metal, however, hardened and ground couplings with stellite inserts have been found satisfactory.

The inspection of rods and tubing in old fields will sometimes reveal a bad pitting of the metal, particularly around the upset of the tubing and rods where the grain structure of the metal has been altered. This is believed to be due to electrolytic corrosion or galvanic action. It is usually bad when large volumes of salt water are produced and when the wells are located in wet or damp ground with the flow lines lying on the ground or buried. The electric currents causing this trouble can be detected by placing a small pocket compass on the lines, rods, or tubing; and their actual magnitude and direction of flow can be measured by millivolt and ammeters. Theoretically, this action can be transferred from the steel by use of metals that are higher in the electrochemical series and that will be attacked in preference to the steel. To test this method of protection two installations were made in which insulated unions were placed in the flow lines to prevent currents from entering the well; the tubing was then grounded to a mass of steel and zinc buried off the derrick floor; and rod couplings containing zinc inserts were installed on every other rod to absorb the galvanic actions in the wells. After 9 months' service it was found that on one well the zinc and steel in the couplings had both been badly pitted, the rods were still in good condition, and the electrolytic action had been spread from

Fig. 2



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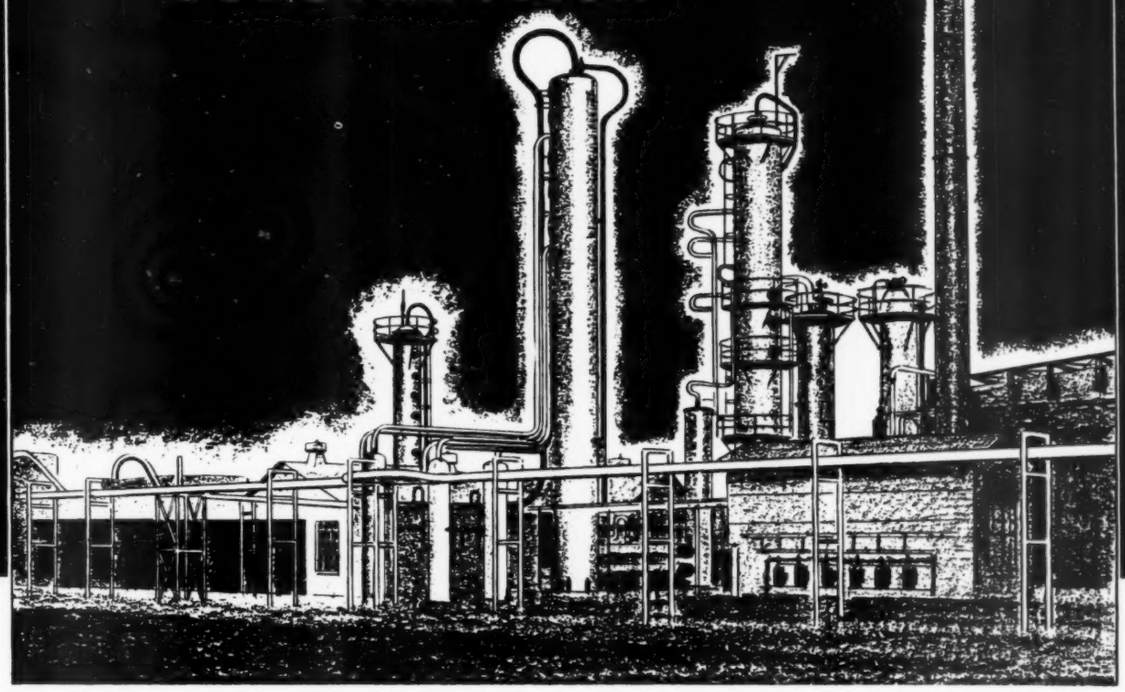

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the upset of the tubing to the entire length of the joint. On the other well the zinc in the couplings had been attacked or eaten up but the steel of the couplings and the rods were in good condition. The tubing, also, showed much less pitting than it had previously. Consequently, no conclusions have been reached but the subject is considered of great importance and is being studied further.

Counterbalancing

For efficient operation of the surface equipment no factor is of greater importance than counterbalancing. One well equipped with a standard rig and single cylinder gas engine had been having trouble with clutch shaft and belt breaks. The correct amount of counterbalance was added to the rig and this trouble was eliminated entirely. Counterbalancing is also particularly important on units powered with multicylinder engines, as the constant acceleration and deceleration of an unbalanced unit will cause rapid wear, excessive oil consumption, and high repair costs. Various methods may be used to balance the unit, but the following are most easily applied in the field:

(1) Slipping the clutch. In this method the unit is turned over slowly by slipping the clutch and the crank positions are noted at the point where it tends to slow down or speed up. Counterbalance is then added in a position tending to give a more constant rotational speed.

(2) Use of a tachometer. This method is especially applicable to multicylinder engines, as little flywheel effect is present and any changes in r.p.m. will be readily noted. A vacuum gauge on the engine manifold may be used in the same manner.

On wells that are pumping at a speed producing a dynamometer card of the second or third harmonic, the well will usually be counterbalanced when a line joining the maximum and minimum load points is perpendicular to the base line of the card. (See Fig. 4.)

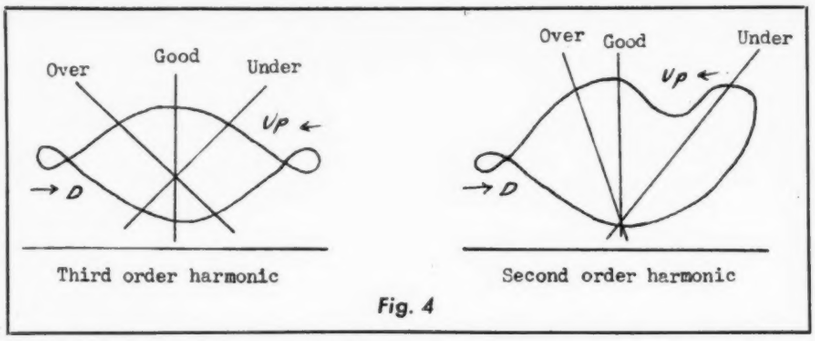


Fig. 4

Prime Mover

The operation of the engine or power unit is closely connected with the pumping unit counterbalance, as this factor determines whether the engine must deliver a relatively low average power input to the unit or high peaks of power at one or more points in the stroke cycle. Of the three types of prime movers, the electric motor is believed to be best from the standpoint of smoothness of power output and the resultant absence of shock loads transmitted through the unit to the rod string. Single cylinder engines should be designed with sufficient WR^2 to absorb the slow speed explosion shocks. In order to maintain operation costs at a minimum on multicylinder engines the following points have been advantageous:

1. Keep pumping unit accurately counterbalanced,
2. Keep crankcase temperatures as high as is practical,
3. For natural gas operation use a volume tank with a fluid seal of kerosine or light oil, and
4. Clean engine periodically with a carbon and sludge solvent.

Table 1 contains some simplified factors that have been found very suitable for simplified calculations of volumes, polished-rod loads, and polished-rod hp. Numerous checks against actual tests have shown that calculations made with these figures are sufficiently accurate for practical purposes in field work. As an example of the methods that may be used in checking the operation of a well in the field, the following conditions are assumed: pumping depth 3600 ft., ⅝-in. sucker rods, 44-in. stroke, 2-in. tubing, 1¾-in. bore pump, and 22 s.p.m. A rapid calculation of expected production would indicate, $35.7 \times 4.4 \times 2.2 \times 0.75 = 260$ bbl. per day. A production test, however, shows that the well is only producing 225 bbl. per day; so, we change the operation as follows:

$$\frac{237{,}000}{3600} = 66 \text{ frequency}$$

using the 3.5 order, we obtain a speed,

$$\frac{66}{3.5} = 19 \text{ s.p.m.}$$

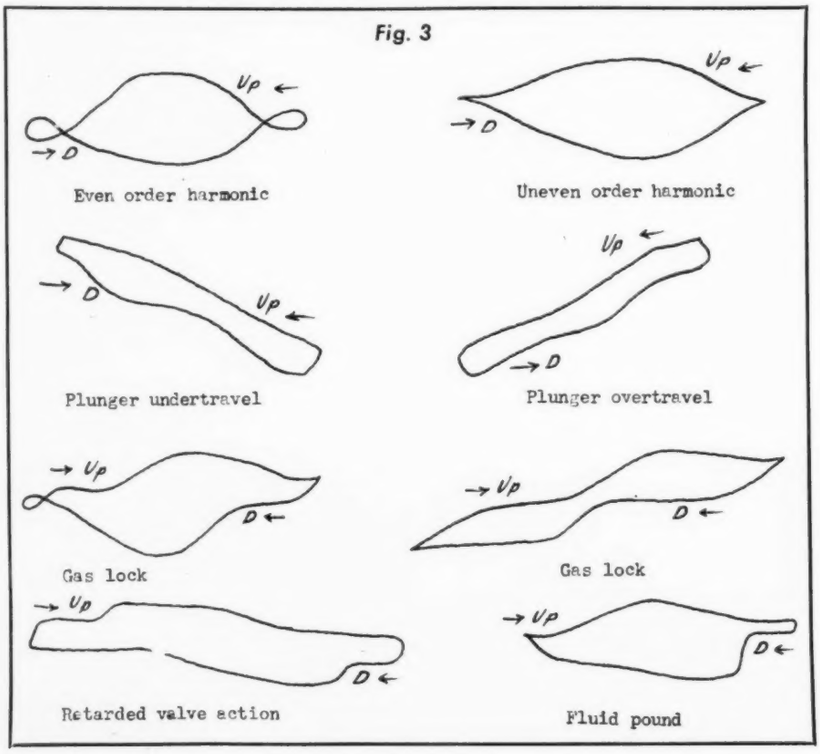
Then, calculated production would be, $35.7 \times 4.4 \times 1.9 \times 0.75 = 224$ bbl. per day.

In this instance the 44-in. stroke is satisfactory. The peak load might then be checked,

Rod weight $= 3.600 \times 1130$
$= 4065$ lb.
Fluid weight $= 3.600 \times 911$
$= 3280$ lb.
Total dead load $= 7345$ lb.

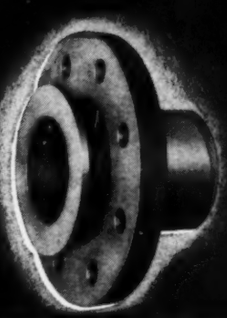
$$\text{Impulse factor} = 1 + \frac{44 \times (19)^2}{70{,}500}$$
$$= 1.22$$

Fig. 3



AMERICAN STANDARD BUTT-WELDING ELBOWS

REDUCING BUTT-WELDING ELBOWS



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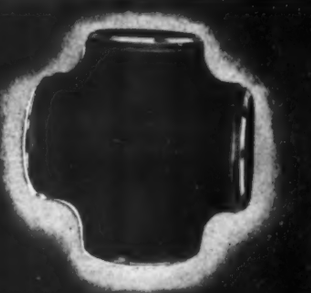
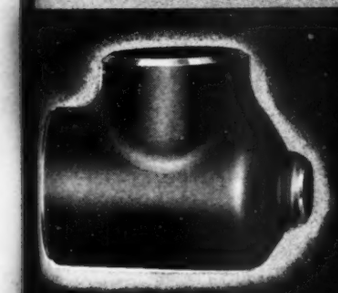
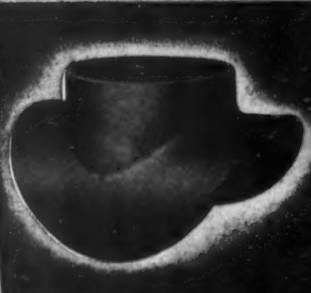


BUTT-WELDING CROSSES



BUTT-WELDING TEES REDUCING ON RUN

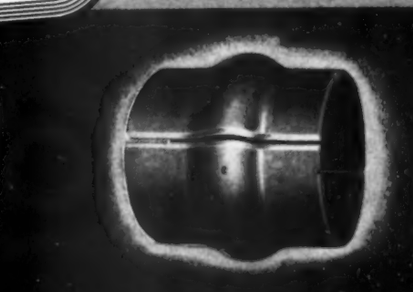


WELDING SADDLES

BUTT-WELDING RETURN BENDS

SHAPED NIPPLES

FORGED STEEL FLANGES



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Peak load = 7345 × 1.22
= 8960 lb.

Polished-rod hp. = $0.264 \times 4.4 \times 1.9 \times 3.600 \times \frac{1}{0.65} = 12.2$ hp.

The hp. thus obtained may be considered as the average hp. actually used.

Peak torque = 8960 × 0.4 × 22
= 78,900 in-lb.

From the A.P.I. figures for pumping unit gear ratings,

$$\frac{78{,}900}{4960} = 15.9 \text{ nominal hp.}$$

$$\frac{78{,}900}{3150} = 25.0 \text{ peak hp.}$$

In actual practice it has been found that a pumping unit slightly above the nominal hp. requirement and a multi-cylinder engine approximating the peak hp. requirement at 1000 ft. per min. piston speed will give a fairly well balanced installation. These figures will naturally be modified by the judgment of the selector for the individual well conditions.

Conclusion

In conclusion, the main factors to consider in an engineering study of a pumping well are:

1. The speed of operation, which should be chosen to give the best harmonic motion in the rod string.
2. The selection of the correct size pump for the fluid to be handled and the proper type pump for the well conditions.
3. The valve action and service in the pump.
4. The service given by the rods and tubing.
5. Correct counterbalancing of the pumping unit.
6. The selection and operation of the prime mover.
7. The spacing of the subsurface equipment.

Thus, the various operating factors may be calculated with reasonable accuracy by simple methods that may be used in the field. These factors must be considered as a whole, as the entire pumping system must operate at maximum efficiency to give the desired result of minimum lifting costs.

Crude Oil Price Structure, Manpower Considered by Petroleum War Council

Authorization of a study of crude oil price structures and appointment of a committee on manpower for the petroleum industry and a technical committee to supervise the technological collaboration necessary to the production of 100-octane aviation gasoline, synthetic rubber, and other war products, concluded the business at the December meeting of The Petroleum Industry War Council, Chairman William R. Boyd, Jr., reported.

At the request of its production committee, which reported an alarming decline in the rate of discovery of crude oil reserves, the Council instructed its committees on cost and price adjustment, and petroleum economics, "to collaborate upon a study of the crude oil price structure with a view to determining those factors which can be expected to stimulate an increase in the rate of discovery of new reserves of crude oil."

Boyd appointed Dr. Robert E. Wilson, president, Pan American Petroleum and Transport Company, New York, chairman, and Robert H. Colley, president, The Atlantic Refining Company, Philadelphia, and W. S. S. Rodgers, president, The Texas Company, New York, to be the Council's new technical committee. This group will plan and supervise the work of an already-functioning technical advisory subcommittee that has been working closely with the Petroleum Administrator in the development of the technological program of petroleum refining for the increased production of petroleum war products.

Another resolution of the Council authorized the chairman to appoint a five-man committee to confer with the Petroleum Administrator and the chairman of the War Manpower Commission upon the numerous manpower problems of the petroleum industry. The committee will be named in a few days, Boyd said.

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TABLE I
Polished-rod loads

Rod size, in.	Rod area, sq. in.	Rod wt., 1000 ft.	Wt. water Per 1000 ft. Spr. gr. 1.0	Pump diameter, in.										
				1	1⅛	1¼	1½	1¾	2	2¼	2½	2¾	3¼	4¼
				Dead weight of rods and fluid										
⅝	0.307	1130		207	251	398	632	911	1230	1590	1990	2440	4650	7540
¾	0.442	1630		149	193	340	574	852	1170	1530	1930	2380	4590	7480
⅞	0.601	2190		80	124	271	505	783	1100	1460	1870	2310	4520	7410
1	0.785	2880		0	44	191	425	704	1020	1380	1790	2230	4440	7330
Bbl. daily per 10-in. stroke per 10 s.p.m. at 100 percent efficiency				11.6	13.2	18.2	26.3	35.7	46.6	59.0	72.9	88.2	164	263
Hp. per 10-in. stroke per 10 s.p.m. per 1000 ft. at 100 percent efficiency				0.086	0.097	0.134	0.193	0.264	0.343	0.435	0.573	0.650	1.21	1.94

Use 75 percent volumetric efficiency for average pump condition. Use 65 percent power efficiency for average pump condition.

Example: 5000 ft. depth, 1¾-in. barrel., 1500 ft. ⅞-in. and 3500 ft. ¾-in., 30° A.P.I. oil, 53-in. stroke, and 20 s.p.m.

Wt. rods = 1.500×2190+3.500×1630 = 9,000 lb.
Wt. fluid = 0.876 (1.500×783+3.500×852) = 3,641 lb.
Total dead load = 12,641 lb.

Impulse factor from Mills' formula:

$$\text{I.F.} = 1 + \frac{\text{stroke} \times (\text{s.p.m.})^2}{70{,}500}$$

$$\text{I.F.} = 1 + \frac{53\text{-in.} \times (20)^2}{70{,}500} = 1.3$$

Peak load = 12,641×1.3 = 16,420 lb.

Production at 75 percent volumetric efficiency = 35.7×5.3×2.0×0.75 = 283 bbl. per day.

Horsepower at 65 percent power efficiency = $0.264 \times 5.3 \times 2.0 \times 5.000 \times \frac{1}{0.65} = 21.0$ hp.

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Crane Co.	160	Oct.	P 615.200.
Cummins Engine Company	138	Nov.	P 683.324.
Dearborn Chemical Company	114	Aug.	P 621.1
Fisher Governor Company (sheet 20)	126	Sept.	P 683.32
Fisher Governor Company (sheet 24)	136	Jan.	P 683.32
Graver Tank & Mfg. Co., Inc.	106	Aug.	P 670.
Hazard Wire Rope Division of American Chain and Cable Co., Inc.	122	Sept.	P 683.321.
Hazard Wire Rope Division of American Chain and Cable Co., Inc. (sheet 2)	140	Jan.	P 546.32
Hyatt Bearings Division, General Motors Sales Corporation (sheet 1)	104	Aug.	P 532.911.
Hyatt Bearings Division, General Motors Sales Corporation (sheet 5)	74	July	P 622.001.
Hyatt Bearings Division, General Motors Sales Corporation	134	Sept.	P 615.222. P 622.24
Hyatt Bearings Division, General Motors Sales Corporation	154	Oct.	P 683.322.
Hyatt Bearings Division, General Motors Sales Corporation (sheet 22)	144	Nov.	P 683.32
Hyatt Bearings Division, General Motors Sales Corporation	130	Dec.	P 622.1
Hyatt Bearings Division, General Motors Sales Corporation	138	Jan.	P 683.327.
Jones & Laughlin Steel Corporation (sheet 23)	126	Dec.	P 683.32
LeRoi Company	108	Aug.	P 425.218.43
LeRoi Company	158	Oct.	P 514.541.
LeRoi Company	142	Nov.	P 516.922.005.
Linde Air Products Company, The	124	Dec.	P 622.4
Ridge Tool Company	162	Oct.	P 546.32
Ridge Tool Company (sheet 2)	144	Jan.	P 590.6
Twin Disc Clutch Company (sheet 2)	136	Nov.	P 670.
Universal Atlas Cement Corporation (sheet 3)	130	Sept.	P 532.911.
Universal Atlas Cement Corporation	122	Dec.	P 425.215.
Vortox Manufacturing Company (sheet 18)	72	July	P 683.32
Vortox Manufacturing Company	164	Oct.	P 683.32
Waukesha Motor Company	128	Sept.	P 615.3
Whitney Chain and Manufacturing Company	132	Sept.	P 621.11
Whitney Chain and Manufacturing Company	140	Nov.	P 615.211.
Whitney Chain and Manufacturing Company	146	Jan.	P 210.0 P 771.0

Static Press.
3200-3295 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	3200	3205	3210	3215	3220	3225	3230	3235	3240	3245	3250	3255	3260	3265	3270	3275	3280	3285	3290	3295
2	80.00	80.24	80.30	80.36	80.43	80.48	80.54	80.61	80.67	80.74	80.79	80.85	80.92	80.98	81.04	81.11	81.16	81.22	81.29	81.35
4	113.4	113.5	113.6	113.7	113.8	113.8	113.9	114.0	114.1	114.2	114.3	114.4	114.5	114.5	114.6	114.7	114.8	114.9	115.0	115.1
6	138.8	138.9	139.0	139.1	139.2	139.3	139.4	139.6	139.7	139.8	139.9	140.0	140.2	140.3	140.4	140.5	140.6	140.7	140.8	140.9
8	160.3	160.5	160.6	160.7	160.8	160.9	161.1	161.2	161.3	161.5	161.6	161.7	161.8	161.9	162.1	162.2	162.3	162.4	162.6	162.7
10	179.3	179.4	179.6	179.7	179.8	179.9	180.1	180.3	180.4	180.5	180.6	180.8	180.9	181.1	181.2	181.4	181.5	181.6	181.8	181.9
12	196.4	196.6	196.7	196.8	197.0	197.2	197.3	197.5	197.6	197.8	197.9	198.1	198.2	198.4	198.5	198.7	198.8	198.9	199.1	199.3
14	212.2	212.4	212.5	212.7	212.8	212.9	213.1	213.3	213.5	213.7	213.8	213.9	214.2	214.3	214.5	214.6	214.8	214.9	215.1	215.3
16	226.8	227.0	227.2	227.3	227.5	227.7	227.8	228.0	228.2	228.4	228.6	228.7	228.9	229.1	229.2	229.4	229.6	229.8	229.9	230.1
18	240.6	240.8	240.9	241.1	241.3	241.5	241.7	241.9	242.1	242.3	242.4	242.6	242.8	242.9	243.2	243.4	243.5	243.7	243.9	244.1
20	253.6	243.8	253.9	254.1	254.4	254.5	254.7	254.9	255.1	255.4	255.5	255.7	255.9	256.1	256.3	256.5	256.7	256.9	257.1	257.3
21	259.9	260.1	260.3	260.5	260.7	260.9	261.0	261.3	261.5	261.7	261.9	262.1	262.3	262.5	262.7	262.9	263.1	263.3	263.5	263.7
22	265.9	266.2	266.3	266.5	266.7	266.9	267.1	267.4	267.6	267.8	267.9	268.2	268.4	268.6	268.8	269.0	269.2	269.4	269.6	269.8
23	271.9	272.2	272.4	272.6	272.8	272.9	273.2	273.4	273.6	273.9	274.0	274.2	274.5	274.7	274.9	275.1	275.3	275.5	275.7	275.9
24	277.8	278.0	278.2	278.4	278.7	278.9	279.1	279.3	279.5	279.7	279.9	280.1	280.4	280.6	280.8	281.0	281.2	281.4	281.6	281.8
25	283.5	283.8	283.9	284.2	284.4	284.6	284.8	285.1	285.3	285.5	285.7	285.9	286.0	286.4	286.6	286.8	287.0	287.0	287.5	287.7
26	289.1	289.4	289.6	289.8	290.0	290.2	290.4	290.7	290.9	291.2	291.4	291.6	291.8	292.0	292.2	292.5	292.7	292.9	293.1	293.3
27	294.6	294.9	295.1	295.3	295.5	295.8	295.9	296.2	296.4	296.7	296.9	297.1	297.4	297.6	297.8	298.0	298.3	298.5	298.7	298.9
28	300.1	300.3	300.5	300.7	301.0	301.2	301.4	301.7	301.9	302.2	302.4	302.6	302.9	303.1	303.3	303.5	303.8	303.9	304.2	304.4
29	305.3	305.6	305.8	306.0	306.3	306.5	306.7	306.9	307.2	307.5	307.7	307.9	308.2	308.4	308.6	308.9	309.1	309.3	309.6	309.8
30	310.5	310.8	311.0	311.3	311.5	311.8	312.0	312.2	312.5	312.7	312.9	313.2	313.4	313.7	313.9	314.2	314.4	314.6	314.9	315.1
31	315.7	315.9	316.2	316.4	316.7	316.9	317.2	317.4	317.7	317.9	318.2	318.4	318.7	318.9	319.1	319.4	319.6	319.8	320.1	320.3
32	320.8	321.0	321.3	321.5	321.8	321.9	322.2	322.5	322.7	323.0	323.2	323.5	323.8	323.9	324.2	324.5	324.7	324.9	325.2	325.4
33	325.7	326.0	326.3	326.5	326.8	327.0	327.2	327.5	327.8	328.0	328.3	328.5	328.8	329.0	329.2	329.5	329.8	329.9	330.3	330.5
34	330.6	330.9	331.1	331.4	331.7	331.9	332.1	332.4	332.7	332.9	333.2	333.4	333.7	333.9	334.2	334.5	334.7	334.9	335.2	335.5
35	335.4	335.7	335.9	336.2	336.5	336.7	336.9	337.3	337.5	337.8	338.0	338.3	338.6	338.8	339.0	339.0	339.6	339.8	340.1	340.3
36	340.2	340.5	340.7	340.9	341.3	341.5	341.8	342.1	342.3	342.6	342.8	343.1	343.4	343.6	343.9	344.2	344.4	344.6	344.9	345.2
37	344.9	345.2	345.5	345.7	346.0	346.2	346.5	346.8	347.0	347.3	347.6	347.8	348.1	348.4	348.6	348.9	349.2	349.4	349.7	349.9
38	349.5	349.8	350.1	350.3	350.6	350.9	351.1	351.4	351.7	351.9	352.2	352.5	352.8	353.0	353.3	353.6	353.8	354.1	354.4	354.6
39	354.1	354.4	354.7	354.9	355.2	355.5	355.7	356.0	356.3	356.6	356.8	357.1	367.4	357.7	357.9	358.2	358.5	358.7	359.0	359.3
40	358.6	358.9	359.2	359.4	359.8	360.0	360.3	360.6	360.8	361.2	361.4	361.7	361.9	362.2	362.5	362.8	363.1	363.3	363.6	363.9
41	363.1	363.4	363.6	363.9	364.2	364.5	364.7	365.0	365.3	365.6	365.9	366.1	366.4	366.7	366.9	367.3	367.5	367.8	368.1	368.4
42	367.5	367.8	368.1	368.3	368.6	368.9	369.2	369.5	369.7	370.1	370.3	370.6	370.9	371.2	371.4	371.8	372.0	372.3	372.6	372.9
43	371 8	372.1	372.4	372.6	372.9	372.3	373.5	373.8	374.1	374.4	374.7	374.9	375.3	375.5	375.8	376.1	376.4	376.6	376.9	377.2
44	376.1	376.4	376.7	376.9	377.3	377.6	377.8	378.1	378.4	378.7	379.0	379.3	379.6	379.9	380.1	380.5	380.7	380.9	381.3	381.6
45	380.3	380.7	380.9	381.2	381.6	381.8	382.1	382.4	382.7	383.0	383.3	383.6	383.9	384.2	384.4	384.8	385.0	385.3	385.6	385.9
46	374.5	384.9	385.1	385.4	385.8	386.0	386.3	386.6	386.9	387.3	387.5	387.8	388.1	388.4	388.7	389.0	389.3	389.6	389.9	390.2
47	388.7	389.1	389.4	389.6	389.9	390.2	390.5	390.9	391.1	391.5	391.8	392.0	392.4	392.6	392.9	393.4	393.5	393.8	394.2	394.4
48	392.8	393.2	393.4	393.7	394.1	393.4	394.6	394.9	395.2	395.6	395.9	396.1	396.5	396.8	397.0	397.4	397.7	397.9	398.3	398.6
49	396.9	397.3	397.5	397.8	398.2	398.4	398.7	399.1	399.4	399.7	399.9	400.3	400.6	400.9	401.2	401.5	401.8	402.1	402.4	402.7
50	400.9	401.3	401.6	401.8	402.2	402.5	402.8	403.1	403.4	403.8	404.0	404.3	404.7	404.9	405.2	405.6	405.9	406.2	406.5	406.8
51	404.9	405.3	405.5	405.8	406.2	406.5	406.8	407.1	407.4	407.8	408.0	408.3	408.7	408.9	409.3	409.6	409.9	410.2	410.5	410.8
52	408.9	409.2	409.5	409.8	410.2	410.5	410.7	411.1	411.4	411.7	412.0	412.3	412.7	412.9	413.3	413.6	413.9	414.2	414.6	414.8
53	412.8	413.1	413.4	413.7	414.1	414.4	414.7	415.0	415.3	415.7	415.9	416.3	416.6	416.9	417.2	417.6	417.9	418.2	418.5	418.8
54	416.6	416.9	417.3	417.6	417.9	418.2	418.5	418.9	419.2	419.6	419.9	420.2	420.5	420.8	421.1	421.5	421.8	422.1	422.4	422.7
55	420.5	420.9	421.2	421.5	421.8	422.1	422.4	422.8	423.1	423.5	423.8	424.0	424.4	424.7	425.0	425.4	425.7	425.9	426.3	426.6
56	424.3	424.7	424.9	425.3	425.6	425.9	426.2	426.6	426.9	427.3	427.6	427.9	428.3	428.6	428.9	429.2	429.5	429.8	430.2	430.5
57	428.1	428.5	428.8	429.1	429.4	429.7	430.0	430.4	430.7	431.1	431.4	431.7	432.1	432.4	432.7	433.1	433.4	433.7	434.0	434.4
58	431.8	432.2	432.5	432.8	433.2	433.5	433.8	434.2	434.5	434.9	435.2	435.5	435.9	436.2	436.5	436.9	437.2	437.5	437.8	438.1
59	435.5	435.9	436.2	436.5	436.9	437.2	437.5	437.9	438.2	438.6	438.9	439.2	439.6	439.8	440.2	440.6	440.9	441.2	441.6	441.9
60	439.2	439.6	439.9	440.2	440.6	440.9	441.2	441.6	441.9	442.3	442.6	442.9	443.3	443.6	443.9	444.3	444.6	444.9	445.3	445.6
61	442.8	443.2	443.5	443.8	444.2	444.5	444.9	445.2	445.6	445.9	446.3	446.6	446.9	447.3	447.6	447.9	448.3	448.6	448.9	449.3
62	446.5	446.8	447.2	447.5	447.9	448.2	448.5	448.9	449.2	449.6	449.9	450.2	450.6	450.9	451.3	451.7	451.9	452.3	452.7	452.9
63	450.0	450.4	450.7	451.1	451.5	451.8	452.1	452.5	452.8	453.2	453.5	453.8	454.2	454.6	454.9	455.3	445.6	455.9	456.3	456.6
64	453.6	454.0	454.3	454.6	455.0	455.4	455.7	456.1	456.4	456.8	457.2	457.4	457.8	458.3	458.5	458.9	459.2	459.5	459.9	460.2
65	457.1	457.5	457.8	458.2	458.6	458.9	459.2	459.6	459.9	460.3	460.7	460.9	461.4	461.7	462.0	462.4	462.8	463.1	463.5	463.8
66	460.6	461.0	461.4	461.7	462.1	462.4	462.7	463.1	463.5	463.9	464.2	464.5	464.9	465.3	465.6	465.9	466.3	466.6	467.0	467.4
67	464.1	464.5	464.8	465.2	465.6	465.9	466.2	466.6	466.9	467.4	467.7	468.0	468.4	468.8	469.1	469.5	469.8	470.1	470.6	470.9
68	467.5	467.9	468.3	468.6	469.0	469.4	469.7	470.1	470.4	470.8	471.2	471.5	471.9	472.2	472.6	472.9	473.3	473.7	474.1	474.4
69	471.0	471.4	471.8	472.1	472.5	472.8	473.2	473.6	473.9	474.3	474.7	474.9	475.4	475.7	476.1	476.5	476.8	477.2	477.6	477.9
70	474.4	474.8	475.2	475.5	475.9	476.2	476.6	477.0	477.3	477.8	478.1	478.4	478.8	479.2	479.5	479.9	480.3	480.6	481.0	481.4
71	478.8	478.2	478.5	478.8	479.3	479.6	479.9	480.4	480.7	481.1	481.5	481.8	482.2	482.6	482.9	483.3	483.7	483.9	484.4	484.7
72	481.1	481.5	481.9	482.2	482.6	482.9	483.3	483.7	484.1	484.5	484.8	485.2	485.6	485.9	486.3	486.7	487.0	487.4	487.8	488.1
73	484.4	484.9	485.2	485.6	485.9	486.3	486.6	487.1	487.4	487.9	488.2	488.5	488.9	489.3	489.7	490.1	490.4	490.8	491.2	491.5
74	487.7	488.2	488.5	488.9	489.3	489.6	489.9	490.4	490.7	491.2	491.5	491.9	492.3	492.6	492.9	493.4	493.8	494.1	494.5	494.9
75	491.0	491.5	491.8	492.1	492.6	492.9	493.3	493.7	494.1	494.5	494.8	495.2	495.6	495.9	496.3	496.7	497.1	497.4	497.9	498.2
76	494.3	494.7	495.1	495.4	495.9	496.2	496.6	497.0	497.4	497.8	498.1	498.5	498.9	499.3	499.6	500.1	500.4	500.8	501.2	501.5
77	497.5	497.9	498.3	498.7	499.1	499.5	499.8	500.3	500.6	501.1	501.4	501.8	502.2	502.5	502.9	503.3	503.7	504.0	504.5	504.8
78	500.8	501.2	501.6	501.9	502.4	502.7	503.1	503.5	503.9	504.3	504.7	505.0	505.5	505.8	506.2	506.6	506.9	507.3	507.8	508.1
79	503.9	504.4	504.7	505.1	505.5	505.9	506.3	506.7	507.1	507.5	507.9	508.2	508.7	509.0	509.4	509.8	510.2	510.5	510.9	511.3
80	507.1	507.6	507.9	508.3	508.7	509.1	509.5	509.9	510.3	510.7	511.1	511.4	511.9	512.2	512.6	513.0	513.4	513.7	514.2	514.5
82	513.4	513.9	514.2	514.6	515.0	515.4	515.8	516.2	516.6	517.0	517.4	517.8	518.2	518.6	518.9	519.4	519.8	520.1	520.6	520.9
84	519.7	520.1	520.5	520.8	521.3	521.7	422.0	522.5	522.9	523.3	523.7	524.1	525.5	524.9	525.2	525.7	526.1	526.4	526.9	527.3
86	525.8	526.3	526.7	527.0	527.5	527.9	528.2	528.7	529.1	529.5	529.9	530.3	530.8	531.1	531.5	531.9	532.3	532.7	533.2	533.5
88	531.9	532.4	532.7	533.1	533.6	533.9	534.3	534.8	535.2	535.7	536.0	536.4	536.9	537.2	537.6	538.1	538.5	538.8	539.3	539.7
90	537.9	538.4	538.8	539.1	539.6	540.0	540.4	540.9	541.2	541.7	542.1	542.5	542.9	543.3	543.7	544.2	544.6	544.9	545.4	545.8
92	543.9	544.3	544.7	545.1	545.6	545.9	546.4	546.8	547.2	547.7	548.1	548.5	548.9	549.3	549.7	550.2	550.6	550.9	551.4	551.8
94	549.7	550.2	550.6	550.9	551.5	551.8	552.2	552.7	553.1	553.6	553.9	554.4	554.8	555.2	555.6	556.1	556.5	556.9	557.4	557.8
96	555.5	556.0	556.4	556.8	557.3	557.7	558.1	558.6	558.9	559.5	559.9	560.2	560.7	561.1	561.5	562.0	562.4	562.8	563.3	563.7
98	561.3	561.8	562.2	562.6	563.1	563.5	563.8	564.3	564.7	565.2	565.6	566.0	566.5	566.9	567.3	567.8	568.2	568.6	569.1	569.5
100	567.0	567.5	567.9	568.3	568.8	569.2	569.6	570.1	570.5	571.0	571.4	571.8	572.3	572.7	573.1	573.6	574.0	574.4	574.9	575.3

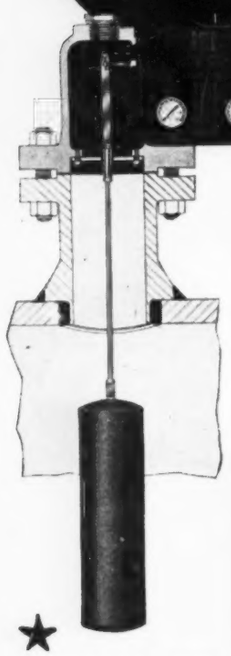
NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water, respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings, intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

WHAT RANGE OF LEVEL CONTROL DO YOU REQUIRE?

LEVEL-TROLS PROVIDE A RANGE FROM 1/2 INCH TO 10 FEET

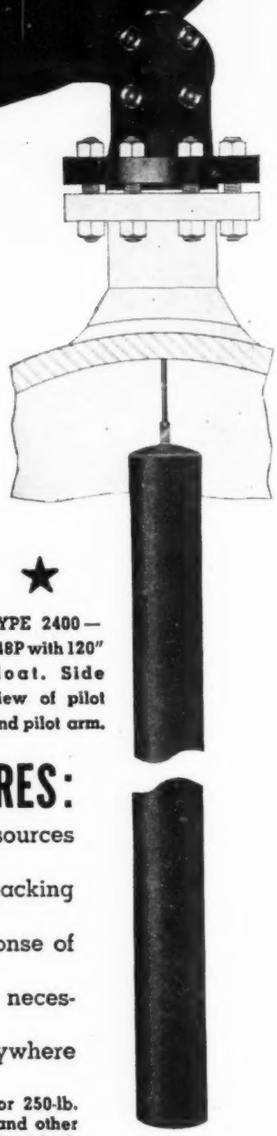


TYPE 2400 — 248P with 14" float. Front view of pilot.

Fisher Type 2400—248P Internal Type Level-Trol makes possible accurate and dependable level control or indication over a range hitherto impossible with float cage and internal ball float type controllers. Tubular float operates on principle of weight measurement of displacement rather than float movement — float moves only relatively small distance in proportion to level change. Floats available in various lengths from 14" to 120" as specified. Pneumatic relay type pilot is full throttling. Suitable for all liquids of all specific gravities at all pressures and temperatures.

LEVEL-TROL APPLICATIONS:

1. Pneumatic Level Controller actuating a remotely installed diaphragm motor valve.
2. Pneumatic Level Indicator actuating a remotely installed indicating gauge.
3. Pneumatic Level Recorder actuating a remotely installed recording instrument.
4. Combination Controller-Indicator, Controller-Recorder, or Indicator-Recorder.



TYPE 2400 — 248P with 120" float. Side view of pilot and pilot arm.

LEVEL-TROL CONSTRUCTION AND OPERATING FEATURES:

1. Extremely sensitive . . . no measurable lag — linkage pivot points and other sources of friction eliminated.
2. Trouble-free operation . . . torque tube construction eliminates stuffing box, packing and lubricator.
3. Quick response to level change — intermittent bleed pilot relay speeds response of diaphragm valve or instrument to level change.
4. Throttling range adjustment makes possible a wide variation in level change necessary to actuate valve or instrument.
5. Level position adjustment permits operator to maintain liquid level range anywhere within the length of the float.

Regularly furnished with auxiliary operating medium regulator and filter. Equipped with 4" 125-lb. or 250-lb. high-tensile iron or 4" 150-lb., 300-lb., 400-lb. or 600-lb. cast steel mounting flange. Type 2400 — 248P and other Level-Trol Types for all service applications are described and illustrated in Bulletin F-1. Copies gladly furnished on request.

FISHER GOVERNOR COMPANY
• 602 FISHER BUILDING •
MARSHALLTOWN, IOWA

24-HOUR CAPACITY* OF 4-IN. BY 2-IN. ORIFICE PLATE—FLANGE CONNECTION

Pressure, lb. per sq. in. ga.	Differential, in. of water										
	5	10	20	30	40	50	60	70	80	90	100
10	288	404	573	702	809	905	993	1071	1146	1216	1281
25	373	482	679	832	962	1076	1177	1273	1361	1441	1522
30	386	547	772	946	1091	1221	1338	1446	1545	1638	1726
40	428	604	855	1047	1211	1353	1480	1599	1711	1815	1913
50	464	658	931	1141	1317	1472	1512	1739	1861	1978	2082
60	500	708	1001	1224	1415	1581	1732	1872	2001	2120	2237
70	531	754	1065	1304	1506	1685	1846	1993	2131	2260	2382
80	563	796	1128	1379	1594	1781	1952	2107	2253	2390	2520
90	594	837	1185	1452	1675	1874	2053	2216	2369	2512	2649
100	620	876	1239	1519	1755	1960	2149	2320	2481	2631	2774
110	645	915	1294	1584	1828	2045	2240	2419	2587	2743	2890
120	671	951	1345	1640	1900	2126	2328	2514	2688	2851	3084
130	697	985	1392	1706	1970	2203	2413	2605	2787	2955	3116
140	723	1019	1441	1765	2038	2279	2496	2696	2880	3056	3222
150	744	1052	1485	1820	2102	2351	2574	2781	2973	3152	3323
160	765	1084	1532	1874	2165	2421	2652	2864	3061	3248	3424
170	785	1112	1573	1929	2227	2489	2727	2945	3150	3339	3520
180	809	1143	1618	1980	2286	2556	2800	3025	3233	3430	3614
190	830	1172	1656	2030	2343	2621	2870	3100	3315	3515	3707
200	848	1200	1698	2079	2400	2683	2940	3175	3396	3601	3795
210	868	1229	1737	2128	2455	2745	3007	3248	3474	3684	3883
220	887	1255	1776	2175	2509	2807	3074	3321	3549	3764	3969
230	907	1281	1812	2219	2564	2864	3139	3391	3624	3844	4052
240	925	1306	1848	2266	2616	2924	3201	3458	3699	3922	4135
250	944	1332	1885	2310	2665	2981	3266	3525	3769	4000	4215
260	959	1358	1921	2351	2717	3036	3326	3593	3842	4072	4295
270	977	1382	1955	2395	2766	3090	3385	3658	3909	4148	4371
280	995	1408	1988	2437	2813	3144	3445	3722	3979	4220	4448
290	1011	1431	2022	2478	2859	3199	3502	3785	4046	4290	4523
300	1029	1454	2056	2517	2906	3251	3559	3847	4111	4360	4596
310	1045	1478	2089	2559	2953	3303	3616	3907	4176	4430	4669
320	1060	1498	2120	2597	2999	3352	3671	3966	4241	4498	4741
330	1076	1522	2152	2634	3043	3401	3725	4026	4303	4565	4811
340	1091	1542	2183	2673	3087	3450	3779	4083	4365	4630	4881
350	1107	1566	2214	2711	3129	3500	3834	4140	4425	4695	4949
360	1122	1586	2242	2748	3173	3546	3886	4197	4487	4759	5016
370	1135	1607	2273	2784	3214	3593	3938	4251	4547	4822	5083
380	1151	1628	2302	2820	3256	3640	3987	4308	4604	4884	5148
390	1167	1649	2330	2854	3297	3686	4039	4360	4663	4946	5213
400	1179	1669	2359	2890	3336	3730	4088	4415	4720	5006	5278
410	1195	1690	2387	2924	3378	3777	4137	4469	4777	5065	5340
420	1208	1708	2416	2960	3417	3821	4184	4521	4832	5125	5402
430	1221	1729	2444	2994	3455	3865	4233	4573	4889	5184	5464
440	1236	1747	2470	3028	3494	3907	4280	4622	4943	5222	5527
450	1249	1768	2499	3059	3533	3951	4326	4674	4995	5299	5586
460	1262	1786	2525	3093	3572	3992	4373	4723	5050	5356	5646
470	1275	1804	2551	3124	3608	4034	4420	4772	5104	5413	5706
480	1288	1822	2577	3157	3645	4075	4464	4822	5148	5467	5765
490	1301	1840	2603	3188	3681	4116	4510	4871	5208	5524	5822
500	1314	1859	2629	3220	3717	4158	4555	4920	5260	6579	5879

4-in. x 2-in. orifice plate size, flange connection.

*Million cu. ft. based on (4-oz.) 14.4 lb. per sq. in., 0.60 gravity, and 60°F. temperature.

1 hour coefficient = 1080.1

24 hour coefficient = 25922.4

Again, THANKS *Industry*

for our 50th and most important year

IN JANUARY, 1942, we gratefully thanked Industry for its half-century of confidence in Hyatt. That message heralded the beginning of the 50th year of Hyatt Roller Bearings.

Since then . . . with our country in peril of its life . . . American industry has thrilled the Allied world with startling feats of production.

Like soldiers on attack, men of the design boards and production lines swung to the job of pouring out the machines that will win this mechanized war.

Industry called on Hyatt for vital bearing assignments in planes, tanks, ships, guns . . . and in the machines that build them.

Creating bearings for such vital service was more than a responsibility. It was a privilege. It was a command!

Without lost motion the whole productive effort of Hyatt became a single aim . . . to rush the most devastating fighting power possible into the hands of our fighters and their allies.

Under the impetus of our fight for freedom, Hyatt precision production has swelled tremendously. This took place despite the many necessary changes made in designs and sizes, tools and methods . . . all having been accomplished without losing a stride in the race against time.

Working with you . . . for America . . . has given us the chance to be extra proud of our fiftieth year, just completed. It was by far Hyatt's most important year . . . in manufacturing achievement and in contribution to the great cause.

Therefore, for giving us a golden opportunity in our golden year, again we say THANKS, INDUSTRY.

Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.

1892 ☆ 1942
Fifty Fifty... FOR 50 YEARS
INDUSTRY AND HYATT PARTNERS IN MECHANICAL PROGRESS

HYATT ROLLER BEARINGS

HORIZONTAL THERMO-SIPHON HEATERS FOR OIL-FIELD OPERATIONS

The tables* on this page are grouped for convenience with brief explanation and should be used only after the article by the authors has been studied and understood.

Table 1 was calculated from the formula: $H = C \times A \times T$; where H is the heat loss from the pipe connecting the heater and gun barrel. C is the number of B.t.u. per hr. transmitted through 1 sq. ft. of exterior pipe surface with temperature difference between pipe and air 1°F. A is the outside surface area of pipe in sq. ft. T is temperature difference between pipe and air °F. Tables 1, 2, and 3 are heat loss tables and are self-explanatory.

Table 4A, B, C, and D is the complete design for application of the heater for gun barrels—illustrated by basic conditions shown in Fig. 1. Example: Assuming outdoor temperature of 40°F., a 20 mile per hr. wind and required to raise temperature of emulsion from 50 to 170°F. at 4.5 bbl. per hr. rate using a wooden tank.

In Table 4A the capacity in bbl. per hr. of emulsion is 4.75, which is above the desired rate and thus satisfactory. Remaining requirements are found in the same column 5 with 16 ft. diameter, 16 ft. height, nominal capacity of 500 bbl., water pipe 3 in., 22.3 ft. of pipe in the heater, a 12½ ft. heater furnace, a furnace chamber of 23 in. width and depth, and a chimney diameter of 11½ in.

TABLE 1

Approximate heat loss from large-diameter uninsulated pipe exposed to 20 mi. per hr. wind

Pipe temperature, °F.	Air temperature, °F.	B.t.u. per hour for 1 sq. ft. of exposed pipe surface
100	40	1030
200	20	1200
200	0	1370
200	−20	1560

TABLE 2

Approximate heat loss from uninsulated steel tanks and wooden tanks exposed to a 20 mi. per hr. wind

Avg. temp. of fluid in tank, °F.	Air temp. outside tank, °F.	Heat loss in B.t.u. per hour from 1 sq. ft. of exposed tank surface			
		Uninsulated steel tank		Wooden tank	
		From side	From deck	From side	From deck
170	40	647	196	59	48
170	20	769	235	68	57
170	0	895	277	78	65
170	−20	1027	322	86	73
170	−40	1173	371	96	82

Example of the use of above table:

A high 500-bbl. steel tank has 780 sq. ft. of surface in the sides and 190 sq. ft. of surface in the deck; therefore, with the average temperature of the fluid in the tank at 170°F. and the outside air temperature 40°F., the heat loss from the sides of the tank in B.t.u. per hour is 780 × 647 or 504,660. The heat loss from the deck equals 190 × 196 or 37,240 B.t.u. per hour. The total heat loss from the tank under these conditions is the sum of the loss from the sides plus the loss from the deck or 504,660 plus 37,240 or 541,900 B.t.u. per hour.

TABLE 3

Heat transmitted to the oil per sq. ft. of contact between oil and water for counter flow (see Fig. 1) with water entering at 190°F. and leaving at 150°F. with final oil temperature of 170°F.

Temperature of incoming oil, °F.	B.t.u. per hour transmitted through 1 sq. ft. of contact surface
50	588
30	658
10	725
−10	793
−30	858

Design data for wooden tanks without emulsion pre-heaters

For simple heaters with 2 water pipes and 1 chamber

TABLE 4A. To increase the temperature of the oil from 50°F. to 170°F. when the outdoor temperature is 40°F., with a 20 mi. per hr. wind.

Diameter of tank, ft	8	10	10	12	16	16	16	22
Height of tank, ft	16	16	20	20	16	20	24	16
Nominal capacity of tank, bbl	135	200	255	380	500 high	660	790	1000
Capacity in bbl. per hour of emulsion	0.76	1.44	1.17	2.02	4.75	4.31	3.87	9.90
Minimum size of water pipe, in	2	2	2	3	3	3	3	4
Number of linear ft. of water pipe in furnace	8.9	14.0	14.6	13.5	22.3	23.0	23.7	30.7
Length of furnace chamber, ft	5½	8	8½	8	12½	12½	13	17
Width and depth of furnace chamber, in	12½	15	15½	18	23	23½	24	31½
Chimney diameter, in	6	7½	7¾	9	11½	11¾	12	15¾

TABLE 4B. To increase oil temperature from 30°F. to 170°F. when outdoor temperature is 20°F., with a 20 mi. per hr. wind.

Diameter of tank, ft	8	10	10	12	16	16	16	22
Height of tank, ft	16	16	20	20	16	20	24	16
Nominal capacity of tank, bbl	135	200	255	380	500 high	660	790	1000
Capacity in bbl. per hour of emulsion	0.7	1.36	1.08	1.89	4.49	4.06	3.64	9.40
Minimum size of water pipe, in	2	3	3	3	3	3	3	4
Number of linear ft. of water pipe in furnace	10.6	10.5	11.0	15.3	25.1	26	26.6	34.4
Length of furnace chamber, ft	6½	6½	6½	9	14	14	14½	18½
Width and depth of furnace chamber, in	13	16	16	19	25	25	25	33
Chimney diameter, in	6½	8	8	9½	12½	12½	12½	16½

TABLE 4C. To increase the temperature of the oil from 10° F. to 170°F. when the outdoor temperature is 0°F., with a 20 mi. per hr. wind.

Diameter of tank, ft	8	10	10	12	16	16	16	22
Height of tank, ft	16	16	20	20	16	20	24	16
Nominal capacity of tank, bbl	135	200	255	380	500 high	660	790	1000
Capacity in bbl. per hour of emulsion	0.64	1.27	1.01	1.77	4.30	3.86	3.44	9.00
Minimum size of water pipe, in	2	3	3	3	4	4	4	6
Number of linear ft. of water pipe in furnace	11.7	11.7	12.2	17	21	21.5	22.2	23.0
Length of furnace chamber, ft	7	7	7½	9½	11½	12	12½	13
Width and depth of furnace chamber, in	14	17	17	20	26	26	27	35
Chimney diameter, in	7	8½	8½	10	13	13	13½	17½

TABLE 4D. To increase oil temperature from minus 10°F. to 170°F. when outdoor temperature is minus 20°F., with a 20 mi. per hr. wind.

Diameter of tank, ft	8	10	10	12	16	16	16	22
Height of tank, ft	16	16	20	20	16	20	24	16
Nominal capacity of tank, bbl	135	200	255	380	500 high	660	790	1000
Capacity in bbl. per hour of emulsion	0.61	1.21	0.94	1.69	4.14	3.71	3.28	8.66
Minimum size of water pipe, in	2	3	3	3	4	4	4	6
Number of linear ft. of water pipe in furnace	13	12.8	13.8	18.6	22.8	23.6	24.3	28.0
Length of furnace chamber, ft	7½	7½	8	10½	12½	13	13½	15
Width and depth of furnace chamber, in	14	18	18	21	27	28	28	37
Chimney diameter, in	7	9	9	10¼	13½	14	14	18¼

*Tables taken from article by Harold Vance and Elmer G. Smith, "Thermo-Siphon Heaters for Oil-Field Operations," The Petroleum Engineer, November, 1942.

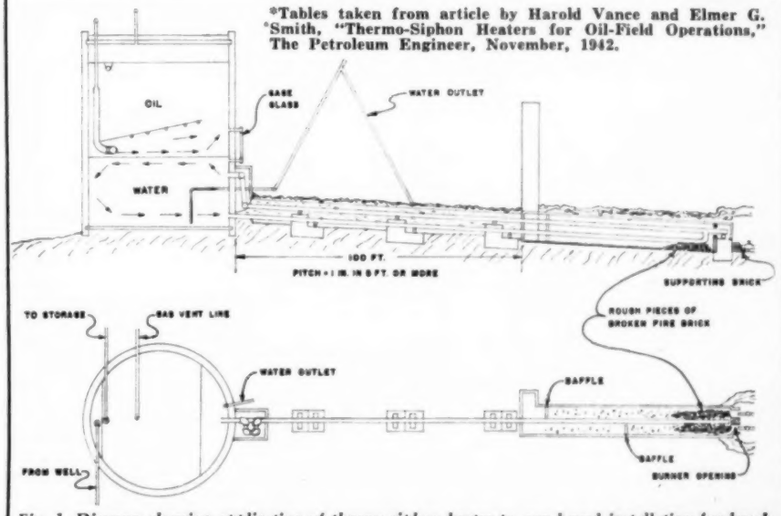


Fig. 1. Diagram showing application of thermo-siphon heater to gun-barrel installation for breaking down emulsions

Correct Lubrication...

If wire ropes are to give their best service—yes, even longer-wearing HAZARD LAY-SET PREFORMED—they must be lubricated regularly—and correctly. Not only will proper lubrication protect the many wires from corrosion and excessive wear, but will permit the internal wires which move one against another when the rope passes over a sheave or winds on a drum, to slide more freely and with less friction. For some short-lived services, factory lubrication is sufficient. For others, additional lubricant must be added in the field, and unless this is done with sufficient frequency, your wire rope is doomed to fail before its proper time. And this is no time to waste steel.

HAZARD LAY-SET PREFORMED WIRE ROPE ordinarily gives so much better, easier-handling, longer service than ordinary non-preformed rope that occasionally operators take its exceptional qualities for granted and forget the oil can. Don't do it. Lubricate your LAY-SET correctly, and you will get even *longer* service—even *greater* dollar value. All Hazard ropes identified by the Green Strand are made of Improved Plow Steel.

HAZARD WIRE ROPE DIVISION

Wilkes-Barre, Pa., Chicago, Pittsburgh, Ft. Worth, Houston, Wichita, San Francisco, Denver, Los Angeles

Distributors in all important oil field centers

AMERICAN CHAIN & CABLE COMPANY, Inc. BRIDGEPORT, CONNECTICUT

● IMPORTANT SUGGESTIONS

Clean wire rope thoroughly before lubricating. Use kerosene and wire brush.

Passing the rope through high-pressure jetted steam has proved a very effective means of cleaning, especially larger diameters.

Wipe off excess lubricant.

Frequent lubrication with light-bodied lubricant is better than infrequent treatment with heavier lubricants.

Lubrication of any wire rope is sufficiently important to warrant calling in one of the industrial lubrication men employed by oil companies or a Hazard man. These men can tell you which lubricant will handle your problems best.

HAZARD LAY-SET *Preformed* ROTARY LINES

24-HOUR CAPACITY* OF 4-IN. BY 1¾-IN. ORIFICE PLATE—FLANGE CONNECTION

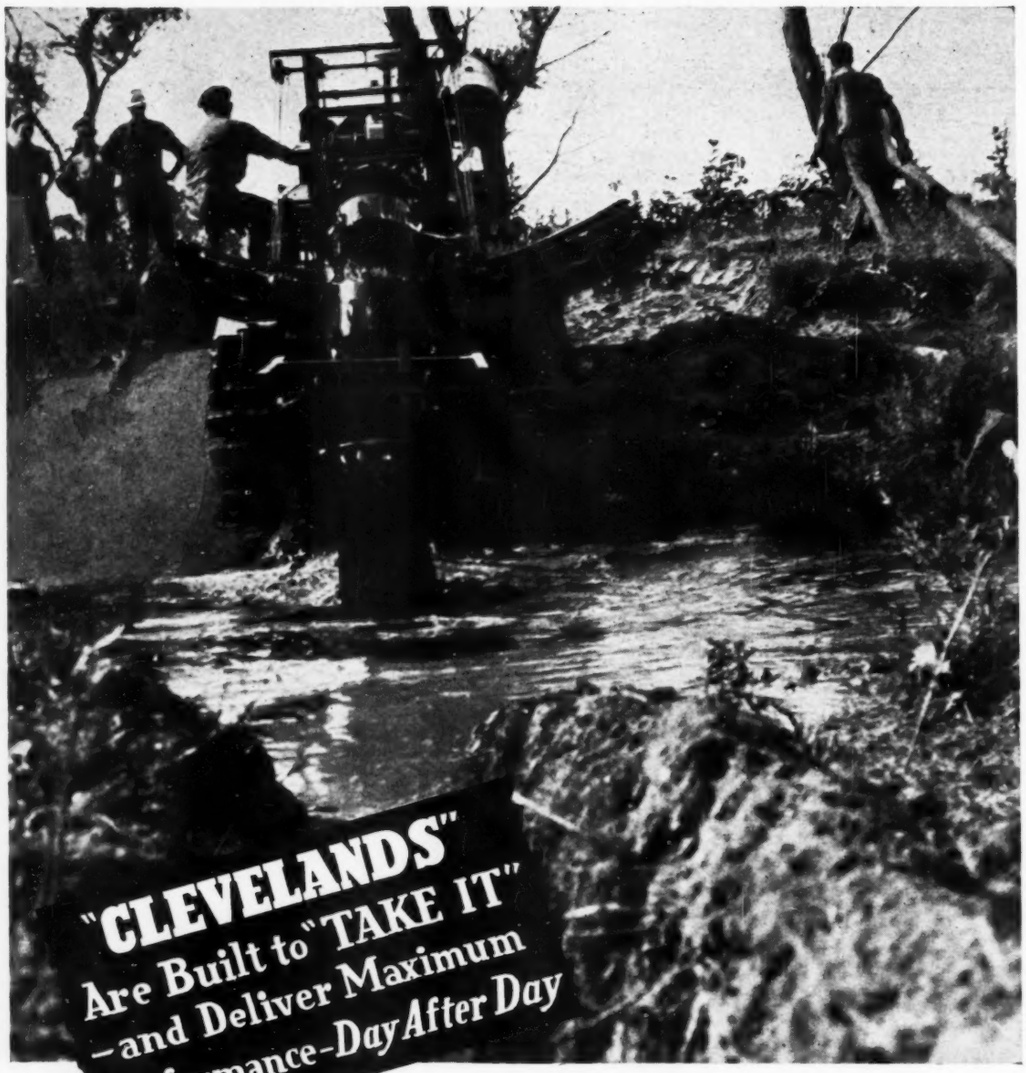
Pressure, lb. per sq. in. ga.	Differential, in. of water										
	5	10	20	30	40	50	60	70	80	90	100
10	217	305	432	530	610	683	749	808	865	918	967
20	282	364	513	628	726	812	888	961	1027	1088	1149
30	292	413	583	714	824	922	1010	1092	1166	1237	1303
40	323	456	646	791	914	1021	1118	1207	1291	1370	1444
50	350	497	702	861	994	1111	1217	1313	1405	1493	1571
60	378	534	755	924	1068	1194	1307	1413	1511	1601	1689
70	401	569	804	984	1137	1272	1393	1505	1608	1706	1798
80	425	601	851	1041	1203	1344	1473	1591	1700	1804	1902
90	448	632	894	1096	1264	1415	1550	1673	1788	1896	2000
100	468	661	935	1147	1325	1479	1622	1751	1873	1986	2094
110	487	691	976	1196	1379	1544	1691	1826	1953	2070	2182
120	507	718	1016	1243	1434	1605	1757	1898	2029	2152	2268
130	526	744	1051	1288	1487	1663	1822	1967	2103	2231	2352
140	546	769	1088	1333	1538	1720	1884	2035	2174	2307	2432
150	562	794	1121	1374	1587	1775	1943	2100	2244	2379	2509
160	578	818	1156	1415	1634	1828	2002	2162	2311	2452	2585
170	593	839	1188	1456	1681	1878	2058	2223	2377	2520	2657
180	610	863	1221	1495	1726	1929	2113	2283	2440	2589	2728
190	626	884	1250	1532	1769	1978	2166	2340	2503	2653	2798
200	640	906	1282	1569	1812	2025	2219	2397	2563	2718	2865
210	656	927	1311	1606	1853	2072	2270	2452	2622	2780	2931
220	669	947	1340	1642	1894	2119	2321	2507	2679	2841	2996
230	685	967	1368	1675	1935	2162	2370	2559	2735	2902	3058
240	699	986	1395	1710	1974	2207	2417	2610	2792	2961	3121
250	712	1006	1423	1743	2012	2250	2465	2661	2845	3019	3182
260	724	1026	1450	1775	2051	2291	2510	2712	2900	3074	3242
270	738	1043	1475	1808	2088	2332	2555	2761	2951	3131	3299
280	751	1062	1501	1839	2123	2374	2600	2810	3004	3186	3358
290	763	1080	1526	1871	2158	2415	2644	2857	3054	3238	3414
300	777	1098	1552	1900	2193	2454	2687	2904	3103	3291	3469
310	789	1115	1577	1931	2229	2493	2730	2949	3152	3344	3524
320	800	1131	1601	1961	2264	2530	2771	2994	3201	3395	3579
330	812	1149	1624	1988	2297	2567	2812	3039	3248	3446	3632
340	824	1164	1648	2017	2330	2604	2853	3082	3295	3495	4685
350	836	1182	1671	2047	2362	2642	2894	3125	3340	3544	3735
360	847	1198	1693	2074	2395	2677	2933	3168	3387	3593	3786
370	857	1213	1716	2102	2426	2712	2972	3209	3432	3639	3837
380	869	1229	1738	2129	2458	2747	3009	3252	3475	3686	3886
390	881	1244	1759	2154	2489	2782	3049	3291	3520	3733	3935
400	890	1260	1781	2182	2518	2816	3086	3332	3563	3778	3984
410	902	1276	1802	2207	2550	2851	3123	3373	3606	3823	4031
420	912	1289	1824	2235	2579	2884	3158	3413	3647	3868	4078
430	922	1305	1845	2260	2608	2917	3195	3452	3690	3913	4125
440	933	1319	1865	2285	2638	2949	3231	3489	3731	3956	4172
450	943	1334	1886	2309	2667	2982	3266	3528	3771	4000	4217
460	953	1348	1906	2334	2696	3013	3301	3565	3812	4043	4262
470	963	1362	1925	2358	2724	3045	3336	3602	3853	4086	4307
480	972	1376	1945	2383	2751	3076	3369	3639	3886	4127	4352
490	982	1389	1965	2407	2779	3107	3405	3677	3931	4170	4395
500	992	1403	1984	2430	2806	3139	3438	3714	3970	4211	4438

4-in. x 1¾-in. orifice plate size, flange connection.

*Million cu. ft. based on (4-oz.) 14.4 lb. per sq. in., 0.60 gravity, and 60°F. temperature.

1 hour coefficient = 815.3

24 hour coefficient = 19567.2



—That's Why "CLEVELANDS" Are "In The Thick Of It" On So Many War Emergency Pipeline Projects . . .

It's Rugged! It's Sturdy! It's Tough! The "CLEVELAND 140." It's outstanding for hard-hitting, day-in and day-out performance.

Amply powered and with a speed for practically every ditching need, it "packs a wallop" that carries it through the toughest going.

Its modern engineering, correct design, coupled with super-quality materials and the best in construction, assures hundreds of hours of operation without major repairs . . . unit type construction permits quick, easy field replacements and repairs when necessary. This means economy of maintenance, a minimum of delays and a big saving of time and labor.

That's why "Clevelands" have been selected for a multitude of projects by the U. S. Military and Naval Services and why for years they have been delivering maximum footage in digging pipeline ditches in all parts of the country.

Keep Your "CLEVELANDS" Fit for the Fight and They'll Give You Long — Faithful Service . . .

Illustrated at right, an important Cleveland feature—Truck Speed Transportation on specially built trailers—Machines load or unload in about 15 minutes.

THE CLEVELAND TRENCHER COMPANY
20100 ST. CLAIR AVE. "Pioneer of the Small Trencher" CLEVELAND, OHIO
"CLEVELANDS" Save More . . . Because they Do More

PREHEATING CHART FOR WELDING

Metal group	Metal designation	Approximate composition, percent								Metal designation	Recommended preheat
		C.	Mn.	Si.	Cr.	Ni.	Mo.	Cu.			
Medium nickel chromium steels	SAE 3115 steel	.15			.60	1.25				SAE 3115 steel	200°F.-400°F.
	SAE 3125 steel	.25			.60	1.25				SAE 3125 steel	300°F.-500°F.
	SAE 3130 steel	.30			.60	1.25				SAE 3130 steel	400°F.-700°F.
	SAE 3140 steel	.40			.60	1.25				SAE 3140 steel	500°F.-800°F.
	SAE 3150 steel	.50			.60	1.25				SAE 3150 steel	600°F.-900°F.
	SAE 3215 steel	.15			1.00	1.75				SAE 3215 steel	300°F.-500°F.
	SAE 3230 steel	.30			1.00	1.75				SAE 3230 steel	500°F.-700°F.
	SAE 3240 steel	.40			1.00	1.75				SAE 3240 steel	700°F.-1000°F.
	SAE 3250 steel	.50			1.00	1.75				SAE 3250 steel	900°F.-1100°F.
	SAE 3315 steel	.15			1.50	3.50				SAE 3315 steel	500°F.-700°F.
	SAE 3325 steel	.25			1.50	3.50				SAE 3325 steel	900°F.-1100°F.
	SAE 3435 steel	.35			.75	3.00				SAE 3435 steel	900°F.-1100°F.
	SAE 3450 steel	.50			.75	3.00				SAE 3450 steel	900°F.-1100°F.
Moly bearing chromium and chromium nickel steel	SAE 3140 steel	.40			.95		.20			SAE 4140 steel	600°F.-800°F.
	SAE 4340 steel	.40			.65	1.75	.35			SAE 4340 steel	700°F.-900°F.
	SAE 4615 steel	.15				1.80	.25			SAE 4615 steel	400°F.-600°F.
	SAE 4630 steel	.30				1.80	.25			SAE 4630 steel	500°F.-700°F.
	SAE 4640 steel	.40				1.80	.25			SAE 4640 steel	600°F.-800°F.
	SAE 4820 steel	.20				3.50	.25			SAE 4820 steel	600°F.-800°F.
Low chrome moly steels	2 percent Cr.-½ percent Mo. steel	Up to .15			2.0		0.5			2 percent Cr.-½ percent Mo. steel	400°F.-600°F.
	2 percent Cr.-½ percent Mo. steel	.15-.25			2.0		0.5			2 percent Ct.-½ percent Mo. steel	500°F.-800°F.
	2 percent Cr.-1 percent Mo. steel	Up to .15			2.0		1.0			2 percent Cr.-1 percent Mo. steel	500°F.-700°F.
	2 percent Cr.-1 percent Mo. steel	.15-.25			2.0		1.0			2 percent Cr.-1 percent Mo. steel	600°F.-800°F.
Medium chrome moly steels	5 percent Cr.-½ percent Mo. steel	Up to .15			5.0		0.5			5 percent Cr.-½ percent Mo. steel	500°F.-800°F.
	5 percent Cr.-½ percent Mo. steel	.15-.25			5.0		0.5			5 percent Cr.-½ percent Mo. steel	600°F.-900°F.
	8 percent Cr.-1 percent Mo. steel	.15 max.			8.0		1.0			8 percent Cr.-1 percent Mo. steel	600°F.-900°F.
Plain high chromium steels	12-14 percent Cr. type 410	.10			13.0					12-40 percent Cr. type 410	300°F.-500°F.
	16-18 percent Cr. type 430	.10			17.0					16-18 percent Cr. type 430	300°F.-500°F.
	23-30 percent Cr. type 446	.10			26.0					23-30 percent Cr. type 446	300°F.-500°F.
High chrome nickel stainless steels	18 percent Cr.-8 percent Ni. type 304	.07			18.0	8.0				18 percent Cr.-8 percent Ni. type 304	Usually do not require preheat but it may be desirable to remove chill.
	25-12 type 309	.07			25.0	12.0				25-12 type 309	
	25-20 type 310	.10			25.0	20.0				25-20 type 310	
	18-8 Cb. type 347	.07			18.0	8.0			Cb.10Xff	18-8 Cb. type 347	
	18-8 Mo. type 316	.07			18.0	8.0	2.5			18-8 Mo. type 316	
	18-8 Mo. type 317	.07			18.0	8.0	3.5			18-8 Mo. type 317	
Irons	Cast iron									Cast iron	700°F.-900°F.
	Ni resist									Ni resist	500°F.-1000°F.
Non ferrous	Aluminum									Aluminum	500°F.-700°F.
	Monel									Monel	200°F.-300°F.
	Nickel									Nickel	200°F.-300°F.
	Inconel									Inconel	200°F.-300°F.
	Copper									Copper	500°F.-800°F.
	Zinc									Zinc	200°F.-300°F.

Preheating prior to welding will

1. Eliminate the danger of formation of cracks.
2. Reduce hardness.
3. Reduce distortion.
4. Reduce or prevent shrinkage stresses.

The need for preheating increases as the following factors are changed

1. The larger the mass being welded.
2. The lower the temperature of the pieces being welded.
3. The lower the atmospheric temperature.
4. The smaller the weld rod in diameter.
5. The greater the speed of welding.
6. The higher the carbon content of the steel.
7. The higher the manganese content.
8. The greater the alloy content in air hardening steels.
9. The more the air hardening capacity of the steel.
10. The greater the difference in mass between the two pieces being joined.
11. The more complicated the shape or section of the parts.

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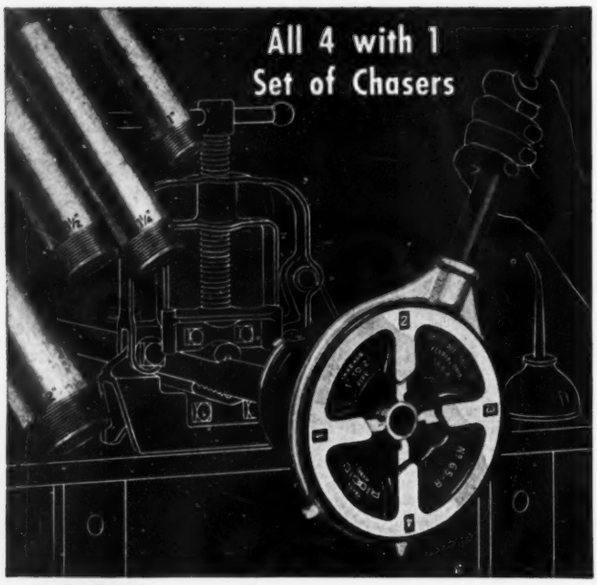
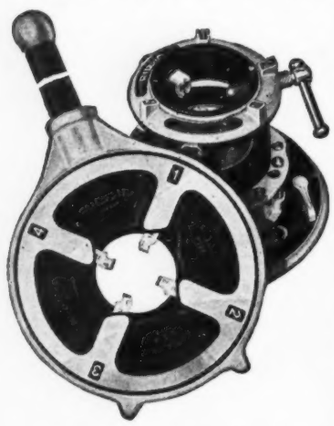


Perfect THREADS

Faster and Easier with this self-contained

RIDGID No. 65R

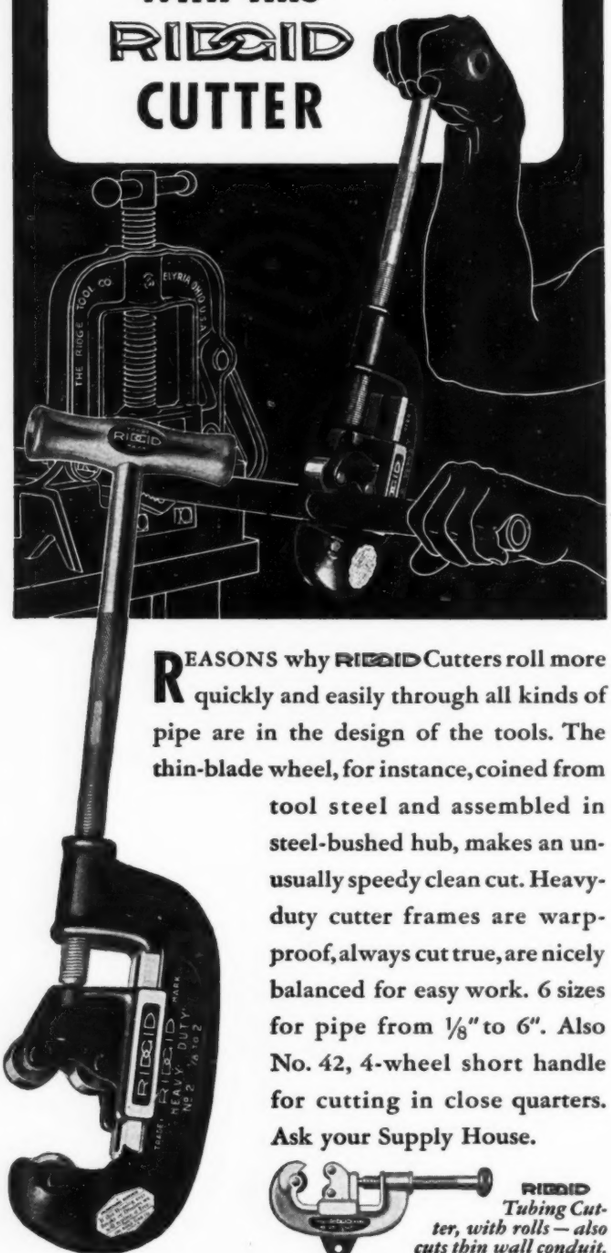
THREADS you cut with this remarkable No. 65R are clean, sharp and of micrometer accuracy — *in all 4 sizes,* 1" to 2" — a new quality in a self-contained die stock. But you'll like also the easy floating cutting action, the 10-second change to pipe size, the instant mistake-proof work-holder without bothersome bushings. It's a rugged steel and malleable tool with high-speed steel and chaser dies, assuring you long trouble-free service. It pays you to ask your Supply House for the RIDGID 65R.



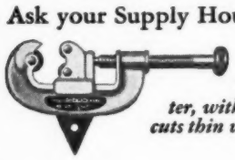
No. 65-R, ratchet and plain, one and two handle, cam or plate type workholders.

All RIDGID Pipe Tools are sold through Supply Houses

When you cut pipe, *Cut Time and Work, too* with this RIDGID CUTTER



REASONS why RIDGID Cutters roll more quickly and easily through all kinds of pipe are in the design of the tools. The thin-blade wheel, for instance, coined from tool steel and assembled in steel-bushed hub, makes an unusually speedy clean cut. Heavy-duty cutter frames are warp-proof, always cut true, are nicely balanced for easy work. 6 sizes for pipe from 1/8" to 6". Also No. 42, 4-wheel short handle for cutting in close quarters. Ask your Supply House.



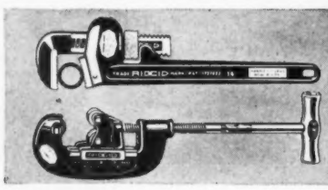
RIDGID *Tubing Cutter, with rolls — also cuts thin wall conduit.*

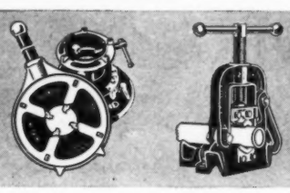
RIDGID

★ PIPE TOOLS ★

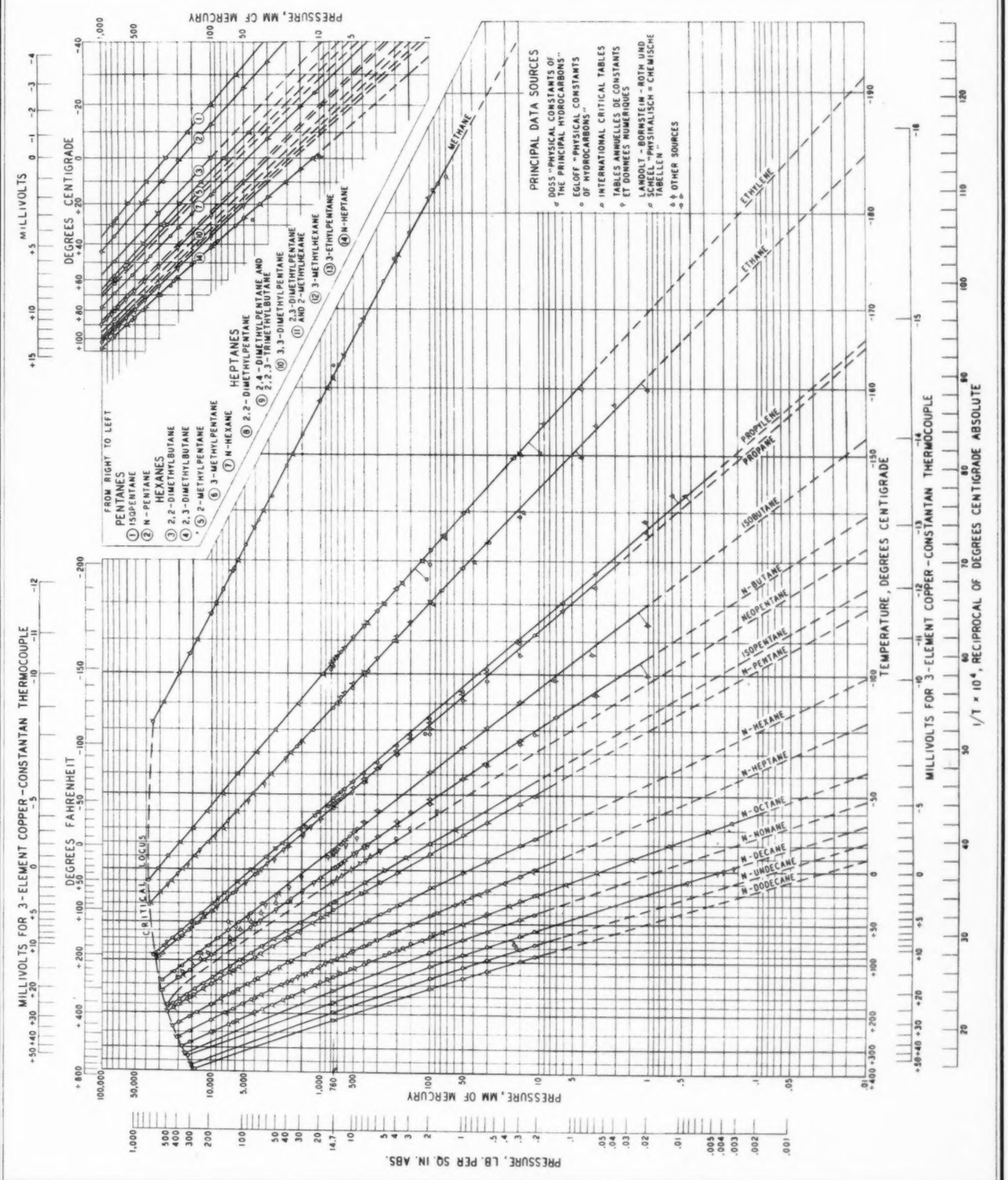
Fast-Working Tools for War . . . and the Busy Peace that's Coming

THE RIDGE TOOL COMPANY
ELYRIA • OHIO • U.S.A.



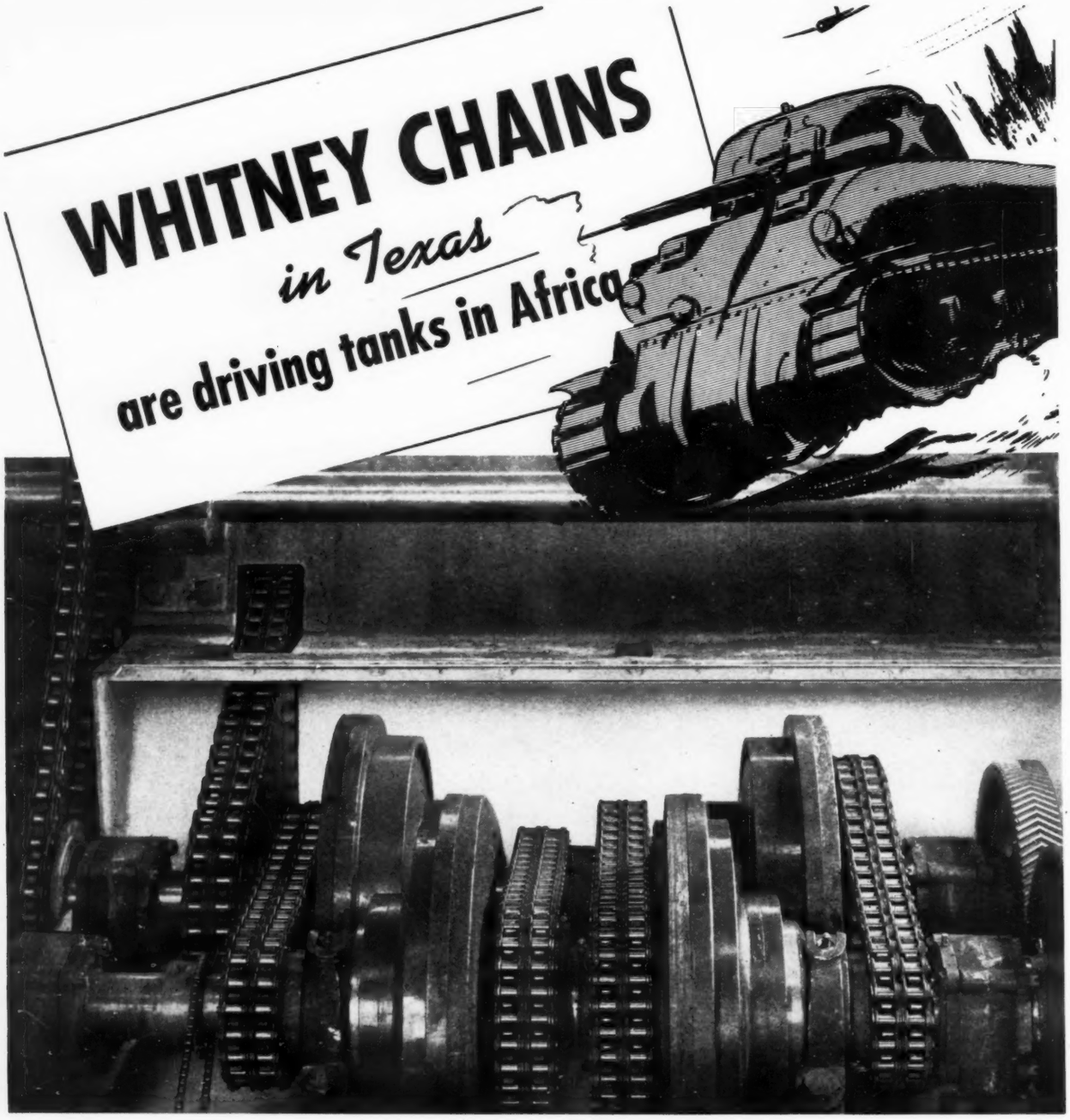


VAPOR PRESSURE CHART FOR VOLATILE HYDROCARBONS[1]



[1]From article, "Vapor-Pressure Chart for Volatile Hydrocarbons," by R. Vincent Smith, U. S. Bureau of Mines, to appear in the February, 1943, issue of The Petroleum Engineer.

WHITNEY CHAINS *in Texas* are driving tanks in Africa



In every American oilfield, thousands of alloy-armored Whitney Roller Chains are keeping production right up to demand on all types of equipment . . . like the Gumbo Buster Draw Works, built by American Well & Prospecting Co. And this full, even flow of power is one of the prime movers in the advance against the Axis, thousands of miles away.

Many other topflight builders of oilfield equipment have, for years, built into their products the positive Performance-Protection of Whitney Roller Chains . . . to assure their customers of maximum power-delivery, plus stubborn resistance to drive-failure even under frequent shocks and overloads. And today this Whitney Chain protection is paying off in uninterrupted operation. So when you buy new equipment — or need replacement chains — get Whitney, the Drive to Victory.

Prolong Chain Life
Keep sprockets aligned, chains lubricated. And inspect *all* drives regularly.

Mid-Continent Sales and Service: *Bull-Stewart Equipment Co., 5219 Grand Ave., Dallas, Texas; Brance-Krachy Co., Inc., 4411 Navigation Blvd., Houston, Texas; Weiss Chain & Transmission Co., 224 East Third St., Tulsa, Okla.; A. D. Guggenheim Co., 227 West 7th Street, Amarillo, Texas; Warford Distributing Co., 319 So. Topeka Ave., Wichita, Kansas; Prager, Inc., 472 Howard Ave., New Orleans, La.* **Mid-Continent Branch Office:** *The Whitney Chain & Mfg. Co., 2826 Elm Street, Dallas, Texas.* **West Coast:** *Edward D. Maltby Co., 1718 So. Flower St., Los Angeles, Calif.*

THE WHITNEY CHAIN & MFG. CO., HARTFORD, CONN.

24-HOUR CAPACITY* OF 4-IN. BY 2¼-IN. ORIFICE PLATE—FLANGE CONNECTION

Pressure, lb. per sq. in. ga.	Differential, in. of water										
	5	10	20	30	40	50	60	70	80	90	100
10	375	527	747	916	1054	1179	1294	1395	1493	1584	1669
20	486	628	885	1084	1253	1402	1534	1659	1774	1878	1983
30	503	713	1007	1233	1422	1591	1743	1885	2013	2135	2250
40	557	787	1115	1365	1578	1763	1929	2084	2230	2365	2493
50	605	858	1213	1486	1716	1919	2101	2267	2426	2578	2713
60	652	922	1304	1595	1845	2061	2257	2439	2608	2763	2915
70	693	983	1388	1699	1963	2196	2405	2598	2777	2946	3105
80	733	1037	1470	1797	2078	2321	2544	2747	2936	3115	3284
90	774	1091	1544	1892	2182	2442	2676	2888	3088	3274	3453
100	807	1142	1615	1980	2287	2554	2801	3024	3233	3429	3615
110	841	1193	1686	2064	2382	2665	2919	3152	3371	3574	3767
120	875	1240	1753	2145	2476	2770	3034	3277	3503	3716	3915
130	909	1284	1814	2223	2567	2872	3145	3395	3632	3851	4061
140	943	1328	1878	2301	2655	2969	3253	3513	3753	3983	4199
150	970	1372	1936	2372	2740	3064	3355	3625	3875	4108	4331
160	997	1412	1997	2442	2821	3155	3456	3733	3990	4233	4463
170	1024	1449	2051	2513	2902	3243	3554	3838	4105	4351	4588
180	1054	1490	2108	2581	2980	3331	3648	3942	4213	4469	4709
190	1081	1527	2159	2645	3054	3415	3740	4040	4321	4581	4831
200	1105	1564	2213	2709	3128	2496	3831	4138	4425	4692	4946
210	1132	1601	2263	2774	3199	3578	3919	4233	4527	4800	5061
220	1155	1635	2314	2834	3270	3659	4007	4328	4625	4905	5172
230	1182	1669	2361	2892	3341	3733	4091	4419	4723	5010	5280
240	1206	1703	2409	2953	3409	3811	4172	4507	4821	5111	5388
250	1230	1736	2456	3010	3473	3885	4257	4594	4912	5213	5493
260	1250	1770	2503	3064	3540	3956	4434	4682	5007	5307	5598
270	1274	1801	2547	3121	3605	4027	4412	4767	5094	5405	5696
280	1297	1834	2591	3176	3665	4098	4490	4851	5186	5500	5797
290	1318	1865	2635	3230	3726	4169	4564	4932	5273	5591	5895
300	1341	1895	2679	3280	3787	4236	4638	5013	5358	5682	5990
310	1361	1926	2723	3334	3848	4304	4713	5091	5442	5773	6084
320	1382	1953	2763	3385	3909	4368	4784	5169	5527	5861	6179
330	1402	1983	2804	3432	3966	4432	4855	5246	5608	5949	6270
340	1422	2010	2844	3483	4023	4496	4925	5321	5689	6034	6361
350	1443	2040	2885	3534	4078	4561	4996	5395	5767	6118	6449
360	1463	2067	2922	3581	4135	4621	5064	5469	5848	6202	6537
370	1480	2095	2963	3628	4189	4682	5132	5540	5925	6284	6625
380	1500	2122	3000	3676	4243	4743	5196	5615	6000	6365	6709
390	1520	2149	3037	3719	4297	4804	5263	5682	6077	6446	6794
400	1537	2176	3074	3767	4348	4861	5327	5753	6152	6523	6878
410	1557	2203	3111	3811	4402	4922	5392	5824	6226	6601	6959
420	1574	2226	3149	3858	4453	4980	5452	5892	6297	6679	7040
430	1591	2253	3186	3902	4503	5037	5517	5959	6371	6756	7121
440	1611	2277	3219	3946	4554	5091	5577	6023	6442	6831	7202
450	1628	2304	3257	3986	4605	5148	4638	6091	6510	6905	7280
460	1645	2328	3290	4030	4655	5202	5699	6155	6581	6979	7358
470	1662	2351	3324	4071	4703	5257	5760	6219	6652	7054	7436
480	1679	2375	3358	4115	4750	5311	5817	6284	6709	7125	7513
490	1696	2399	3392	4155	4797	5365	5878	6348	6787	7199	7588
500	1713	2422	3426	4196	4844	5419	5936	6412	6854	7270	7662

4-in. x 2¼-in. orifice plate size, flange connection.

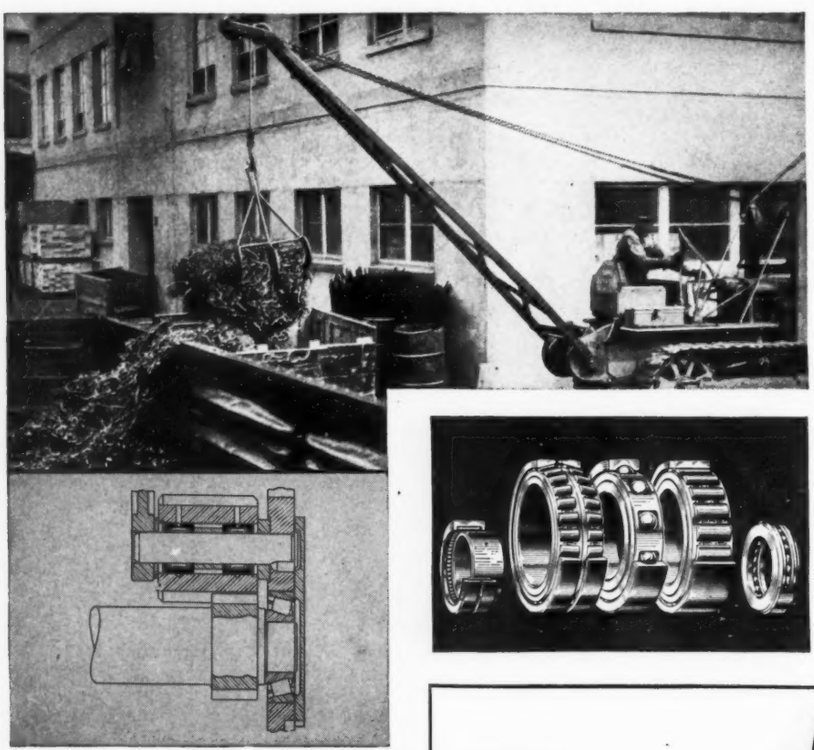
*Million cu. ft. based on (4-oz.) 14.4 lb. per sq. in., 0.60 gravity, and 60°F. temperature.

1 hour coefficient = 1407.6

24 hour coefficient = 33782.4

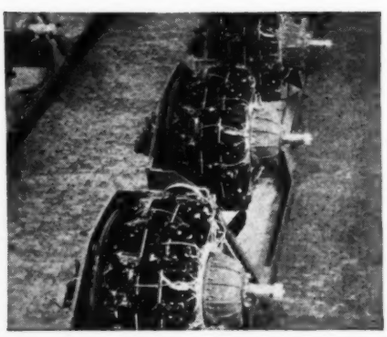
IN THE NEWS
WITH BANTAM BEARINGS

70 TONS OF FLYING BOAT, the Mars provides a new cargo carrier of tremendous speed, and offers a forecast of the aerial transportation of the future. Built for the Navy by The Glenn L. Martin Company, the Mars, with its 200-foot wing spread and its four 2000-HP motors, requires a giant beaching gear to maneuver it on land. And in the gear the entire load is carried on large-size Bantam Ball Thrust Bearings made of stainless steel to resist attack by salt air and water—another instance of Bantam's skill in supplying bearings for radically new requirements.



FROM TOWING WINCH TO CRANE by the addition of a boom is the transformation undergone by this versatile Willamette Hyster winch, now handling scrap in a metal refining plant. Winches of this type use Bantam Quill Bearings on reverse idler pinion (as shown in cross-section drawing) and in idler gear.

THE GENERAL GRANTS CAN TAKE IT, as these 30-ton tanks conclusively demonstrated in the Egyptian campaign. And in the tank transmissions, Quill Bearings are again proving their ability to perform efficiently and reliably under the most severe service conditions. For further information on this compact, high-capacity anti-friction bearing, write for Bulletin P-104.



BANTAM NEEDLE ROLLERS are assembled into anti-friction units of exceptionally high load capacity, low cost, and small size, for use in many of America's foremost aircraft engines. Where anti-friction is a *must*, and size, weight, and installation are factors in design, Bantam Needle Rollers fill many important jobs.

←IF YOU NEED ANTI-FRICTION BEARINGS for war applications or tomorrow's designs, you will probably find what you want among Bantam's comprehensive line, which includes straight roller, tapered roller, needle, and ball. Or if you need *special* bearings, Bantam engineers will design them. For help on your bearing problems, TURN TO BANTAM.

BANTAM BEARINGS

STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

Running Tour

WITH MEN IN THE INDUSTRY

PAUL R. KING, formerly district manager for the Pittsburgh Steel Company, at Houston, Texas, is now a first lieutenant in the U. S. Army Chemical Service.

LEO E. HINES, formerly petroleum engineer with the Cotton Valley Operators Committee, Cotton Valley, Louisiana, has received a commission as lieutenant in the Engineer Corps of the U. S. Army. His address is Lt. Leo E. Hines, A. P. O. 10160, care Postmaster, Seattle, Washington.

CHAS. J. ROUNTREE, who returned to the states July 20, 1942, from Caracas, Venezuela, where he had been a driller for the Socony-Vacuum Oil Company, is at present a volunteer in the Naval Construction Battalion, Rhode Island. His address is 46 Battalion, Company C, Platoon 5, Camp Endicott, Davisville, Rhode Island.

JOE J. KING, formerly engineer with The Texas Company, Houston, Texas, is now a first lieutenant with the U. S. Army Engineer Corps and gives his address as Office of Chief of Engineers, Room 1102, New War Department Building, Washington, D. C.

STARR THAYER, Houston, Texas, consulting engineer specializing in cathodic protection, recently returned from the Caribbean area where he spent several weeks doing work on the protection of equipment for the U. S. Army.

DR. CHARLES D. LOWRY, JR., of Universal Oil Products Company, Chicago, Illinois, will discuss "Recent Developments in the Technology of Petroleum Refining," before the Maryland Section of the American Chemical Society, at Baltimore, on January 22.

WALTER M. DICK, treasurer of the Westinghouse Electric Supply Company, retired December 31, 1942, after 40 years' service. Dick joined the Westinghouse Electric and Manufacturing Company October 1, 1901, in the accounting department at Pittsburgh, Pennsylvania. He became a traveling auditor in 1907 and chief field auditor in 1915.

DR. NICHOLAS N. T. SAMARAS and ROY W. SUDHOFF have been promoted to assistant directors of the central research department of Monsanto Chemical Company, St. Louis, Missouri, according to an announcement by DR. CHARLES ALLEN THOMAS, director, and DR. CARROLL A. HOCHWALT, associate director. The two research scientists have been leaders of experimental research groups in the Monsanto laboratories.

ORVILLE ADAMS, engineer with the Guiberson Diesel Engine Company,

ORVILLE ADAMS

Dallas, Texas, has been commissioned a lieutenant (s.g.) in the U. S. Naval Reserve.

BEN H. RAVANELL, formerly development engineer for Oil Well Supply Company and later tool engineer for Guiberson Diesel Engine Company, is now with Continental Motors Corporation as superintendent in charge of assembly and test of tank engines. He recently spent several days studying methods used and viewing progress at the Detroit, Michigan, plant of the company.

DR. BLAINE B. WESCOTT, chief of the materials and products chemistry division of the Gulf Research and Development Company, Pittsburgh, Pennsylvania, has been appointed to membership of the Sectional Committee on Pipe Threads of the American Standards Association.

ALBERT C. DELMONT, formerly doing consulting work on Naval ordnance production, has been appointed research director of the newly-organized research and laboratory departments of the Douglas T. Sterling Company, management consultants, of Stamford, Connecticut, it is announced by DOUGLAS T. STERLING. Sterling gave as the basic reason the increasingly important need for post-war planning.

J. F. M. TAYLOR and H. BLOEMGARTEN have been appointed vice-presidents of the Shell Oil Company, Inc., east of the Rockies, effective January 1, it is announced by ALEXANDER FRASER, president of the company.

Taylor as vice-president of manufacturing, succeeds E. D. Cumming, who has been granted an indefinite leave of absence and was recently appointed director of refining under the Petroleum Administrator for War.

Bloemgarten, who for the last year has been special assistant to the president in exploration and production operations, will continue to deal with this phase of the business in his new capacity.

E. A. SEELEY, manager of field personnel and training for The B. F. Goodrich Company, has been loaned to the Army Ordnance Department's Tank and Automotive Center, Detroit, Michigan, as executive personnel advisor. R. A. MAXWELL, with Goodrich since 1933, has gone into government service as a member of the requirements and capacities section, rubber branch of the War Production Board, the company announces. L. R. HOWES is now sales engineer for the automotive and aeronautic departments of Goodrich national sales and service division with headquarters in the B. F. Goodrich Company plant, 5400 East Olympic Boulevard, Los Angeles, California, it is announced by DONALD W. FAIRBAIRN, district manager of that division of the Pacific Coast.

STARK FOX, associated with Oil Producers Agency of California for the last five years, and with the Conservation Committee of California Oil Producers for the last two and one-half years, has been appointed a lieutenant (j.g.) United States Naval Reserve, and reported at Quonset Point, Rhode Island, on December 22 for training for administrative duties in the Navy's Air Corps.

B. R. GOSSETT, assistant district superintendent for the Humble Oil and Refining Company in the Raccoon Bend district, has been transferred to the Lovell Lake district on the Texas Gulf Coast.

R. W. ERWIN of Salt Water Control, Inc., Tyler, Texas, has been elected chairman of the East Texas Section of A. I. M. E., to serve for the year 1943. Erwin succeeds A. S. Rhea.

R. W. ERWIN

Other officers elected are: Vice-chairmen: D. W. AKINS, JR., The Ohio Oil Company, Shreveport, Louisiana, and J. S. FULLER, Oil Well Supply Company, Dallas, Texas.

Secretary-treasurer: R. M. HESS, Shell Oil Company, Inc., Kilgore, Texas.

Board of Directors: A. S. RHEA, East Texas Salt Water Disposal Company, Kilgore, Texas; W. E. WINN, Sun Oil Company, Dallas, Texas, and R. O. GARRETT, Arkansas Fuel Oil Company, Shreveport.

W. F. KNODE, consulting petroleum engineer, moved January 1 to Fort Worth, Texas. His office address is 1004 Fort Worth National Bank Building.

HENRY J. MELCHERT has been appointed distributor for Hamer Oil Tool Company in Illinois. Melchert's office is at 122 South Michigan Avenue, Chicago.

KURT DE COUSSER, Lansing, Michigan, head of Socony-Vacuum Oil Company land and geological division in Michigan, has been reelected president of the Oil and Gas Association of Michigan for 1943. All other officers of the association were reelected,

ERIC L. KOHLER, Chicago, Illinois, consulting accountant, who recently served with the War Production Board, has received appointment as executive officer of the PAW (Petroleum Administrator for War) office, according to an announcement by Deputy Administrator RALPH K. DAVIES. He will serve as executive assistant to Davies in handling organizational and administrative problems.

JERE IVY, Carter Oil Company safety engineer of Tulsa, Oklahoma, succeeds J. D. MCCAMEY, who is now in the U. S. Army Engineer Corps.

J. W. RAYBURN, Tide Water Associated Oil Company, Tulsa, Oklahoma, has been reelected president of Petroleum Motor Transport Association of Oklahoma. C. E. JACKSON, a past president, and HOMER NEWBY, Cities Service Oil Company, Bartlesville, were elected vice-presidents. W. H. ESSER, Shell Oil Company, Inc., Tulsa, was elected secretary-treasurer.

EDDIE GRISWOLD, engineer and independent operator, has succeeded E. A. WAHLSTROM as chief engineer of the Goldsmith Engineering Committee. Wahlstrom was granted a leave of absence to accept a commission as lieutenant in the U. S. Naval Reserve. An executive committee selected to assist and advise Griswold is composed of DEWEY A. JORDAN, The Atlantic Refining Company, Midland, chairman; J. W. HOUSE, Humble Oil and Refining Company, Midland, secretary; M. L. ATKINSON, Phillips Petroleum Company, Odessa; O. F. HEDRICK, Texas Pacific Coal and Oil Company, Midland; R. R. PORTERFIELD, Devonian Oil Company, Midland; G. A. POOLE, Gulf Oil Corporation, Odessa; PAUL OLES, Clifford Moers Company, Midland, and GEORGE CARD, Stanolind Oil and Gas Company, Fort Worth.

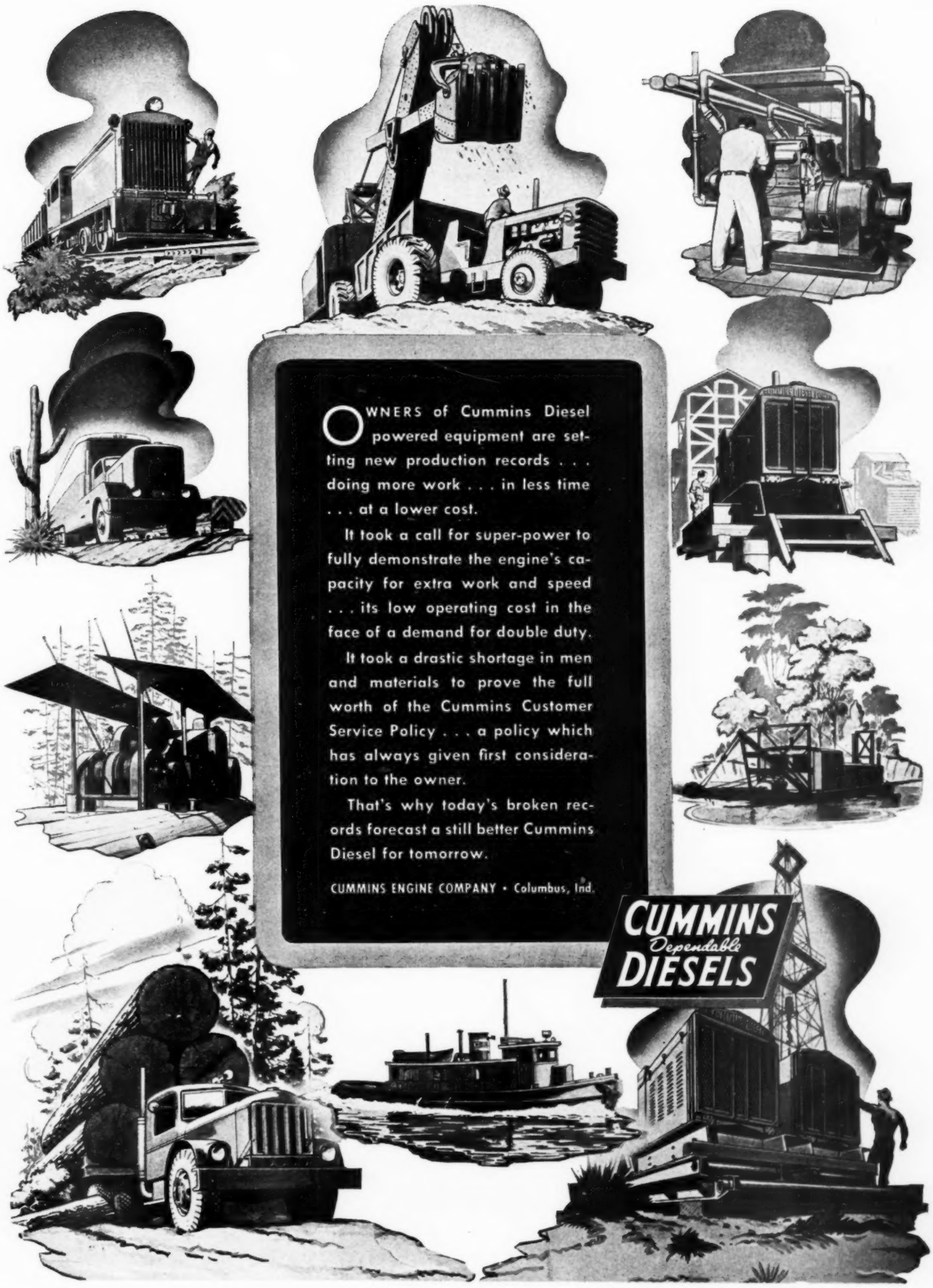
W. M. MCELROY, associated with General Petroleum Corporation for more than 25 years, is now manager of the company's refining department.

CAPTAIN JOHN W. HERBERT, 43, Fort Worth civic leader and president of Herbert Oil Company and Falcon Company, was killed November 24 while on a combat mission for the U. S. Army Air Corps in New Guinea. Herbert entered the oil business at the time of the boom at Burkburnett and later discovered several pools in Texas.

WILLIAM R. BOYD, JR., chairman of the Petroleum Industry War Council and president of the American Petroleum Institute, said a committee had been appointed to make a study of the problems growing out of the possible termination of forfeiture of oil and gas leases because of government orders and directives that make it impossible for the industry to comply with lease obligations and similar commitments. The committee consists of CHARLES I. FRANCIS of Vincent, Elkins, Weems and Francis, Houston, Texas, chairman; FORREST M. DARROUTH, Carter Oil Company, Tulsa; DON EMERY, Phillips Petroleum Company, Bartlesville, Oklahoma; A. M. GEE, Ohio Oil Company, Findlay, Ohio; L. A. GIBBONS, Union Oil Company of California, Los Angeles; WALLACE E. HAWKINS, Magnolia Petroleum Company, Dallas, Texas; WILLIAM L. HOLLOWAY, Honolulu Oil Corporation, San Francisco, California; GILBERT MUELLER, Argo Oil Company, Denver, Colorado, and G. T. STANFORD, Consolidated Oil Corporation, New York, New York.

O. W. TRUMBULL, formerly of Asbestos Textile Company, is now connected with Greene, Tweed and Company of New York, New York.

New officers for the Dallas Petroleum Engineers Club elected at the last meeting of the year are, left to right, E. T. EGGERS, American Steel and Wire Company, vice-president in charge of membership; CHAS. B. CARPENTER, U. S. Bureau of Mines, executive vice-president in charge of programs; HORACE SANDERS, Cooper-Bessemer Corporation, president; L. T. POTTER, Lone Star Gas Company, vice-president in charge of entertainment, and J. W. BLACK, Magnolia Petroleum Company, secretary-treasurer.


OWNERS of Cummins Diesel powered equipment are setting new production records . . . doing more work . . . in less time . . . at a lower cost.
It took a call for super-power to fully demonstrate the engine's capacity for extra work and speed . . . its low operating cost in the face of a demand for double duty.
It took a drastic shortage in men and materials to prove the full worth of the Cummins Customer Service Policy . . . a policy which has always given first consideration to the owner.
That's why today's broken records forecast a still better Cummins Diesel for tomorrow.
CUMMINS ENGINE COMPANY • Columbus, Ind.
CUMMINS
Dependable
DIESELS

MID-CONTINENT SUPPLY COMPANY, FORT WORTH, TEXAS • ***Distributors Mid-Continent Territory***

LAUGH WITH BARNEY

Hail to the Roughneck

By Billy McGraw
Poet Laureate, Los Angeles Nomads

On the derrick floor he stands,
With grimy face and muddy hands,
And on his lips a ready jest,
Through hardest work or moment's rest.

To unknown salesmen who would know,
The depth of hole and why it's so,
His dumbness is a cause to weep,
He only knows it's round and deep.

When round the job for news you beg,
He's hard boiled as a picnic egg,
But should hard luck be yours in time,
He'll share with you his thinnest dime.

You've known collectors, I surmise,
Of stamps, and coins, and butterflies,
But they fade out like distant stars,
Beside collectors of cigars.

So hail to one without a care,
The answer to a maiden's prayer,
Who wades through life so free from guile,
The roughneck with his ready smile.

—*Flying Carpet.*

* * *

The chap was before the sugar rationing board. "My wife has no sugar at all in our house—not an ounce!" The chairman of the board warned him, "Remember you are swearing to this. You must tell the truth or you'll go to jail." The chap thought for a moment, "Gotta tell the truth, eh? In that case rather than do a stretch in jail I'll tell you. We ain't married!"

* * *

A woman flees from temptation, but a man just crawls away from it in the cheerful hope that it may overtake him.

* * *

"I'll do it slower this time," said the newly married magician who stayed up half the night showing his new bride all his card tricks.

* * *

Cafe Sign

Hard boiled eggs	1 cent
Wear and tear on chickens	3 cents
Rooster's fee	1 cent
Total	5 cents

* * *

A wedding carriage was seen driving through the streets of London the other morning. Inscribed in chalk on the back were the words "Result of Careless Talk."

"Mrs. McCoy," said the iceman, "as my route has been changed, I'm going to have to make you an hour later from today on."

* * *

Lecturer: Potts was a great man. At his death three towns were named after him—Pottstown, Pottsville, and Chambersburg.

* * *

Willie: I killed five flies today—three males and two females.

Johnny: How can you tell a male from a female?

Willie: Well, three sat on the beer bottle and two on the mirror.

* * *

Hotel Clerk: Pardon me, Mister, but how did you happen to be named J. John B. B. Bronson?

Patron: I was christened by a minister who stuttered.

* * *

A certain famous motor car manufacturer advertised that he had put a car together in seven minutes. The next evening he was called on the phone at dinner time and asked if it were so.

"Yes," was the reply. "Why?"

"Oh, nothing. But I believe I've got the car."

* * *

"Elenita, do you know your alphabet?"

"Yes, papa."

"Then let's see, what letter comes after A?"

"All of them, papa."

* * *

Junior Senator: When somebody comes around with a new theory, you always endorse it. Why is that?

Senior Senator: I'd rather endorse it than have it explained to me.

* * *

The Smiths were in conference about hiring a certain applicant for cook:

Mr. Smith: Don't take her. I don't like her looks.

Mrs. Smith: But consider the reputation for cooking she bears.

Mr. Smith: Makes no difference. We don't want any she bears cooked anyway; we don't like 'em!

* * *

Doctor: Nurse, you've been with that handsome patient in 402 over an hour.

Nurse: Don't stop me now. I've got to get a thermometer.

Doctor: Gosh, is he running a temperature?

Nurse: No, but I am.

"Mandy, I've heard about your hard luck. I'm terribly sorry."

"Deed, ma'am, ah ain't had no hahd luck."

"But, your husband; wasn't he killed in an accident yesterday?"

"Yes, ma'am, but dat's his hahd luck, not mine."

* * *

It was a cold night. They snuggled on the sofa before the fire. He had talked himself out without saying anything. She thought him slower than a telegraph boy in a hurry.

"Do you notice how the fire reddens?"

"Yes," she sighed deeply, "but I'm sure it's not because of anything we have done."

* * *

"Are you a good golf player?"

"Yes and no."

"What do you mean?"

"Yes, I am no good."

* * *

Tramp at back door: Madam, I don't even know where my next meal is coming from.

Lady at door: Well, this is no information bureau.

* * *

Traffic Officer: As soon as I saw you come around the curve I said to myself, "Forty-five at least."

Woman Driver: Well, I'll be honest with you—you're off. It's this hat that makes me look so old.

* * *

"Don't you ever use toothpaste?"

"Why should I when I have no teeth loose?"

* * *

"Billy! Billy!"

"What, Ma?"

"Are you spitting in the fishbowl?"

"No, Ma, but I'm coming pretty close!"

* * *

Molly: When George and I get married we're going to Mexico to see what it's like.

Myrtle: It's all right—in fact it's fine.

* * *

"Look at that youngster, the one with the cropped hair, the cigarette and trousers on. It's hard to tell whether it's a boy or girl."

"She's a girl and she's my daughter."

"My dear sir, do forgive me, I would never have been so outspoken if I had known you were her father."

"I'm not her father, I'm her mother."

General Heading:

BAKER ROTARY WALL SCRAPER and BAKER ROTARY WALL SAMPLER

Unit No: A-22

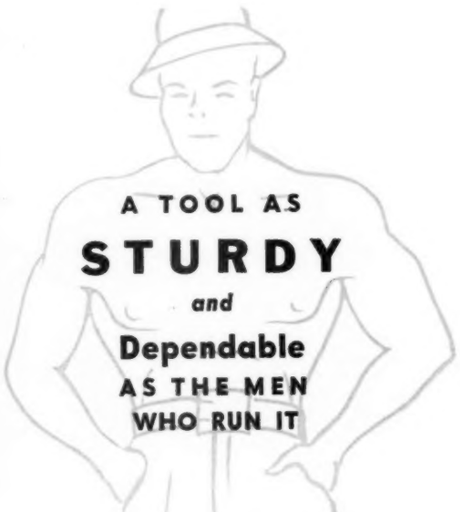
Subject:

A Simple Solution to Hole Enlarging and Wall Scraping Problems

BAKER OIL TOOLS, INC.

Main Office and Factory:
6000 So. Boyle Ave., Box 127, Vernon Station, Los Angeles, Calif.
Central Division Office and Factory:
6023 Navigation Blvd., Box 3048, Houston, Texas
Export Sales Office:
19 Rector Street, New York, N. Y.

Index: 250.1
Date: January, 1943
Page: 1 of 1 pg.



Drilling crews are a sturdy, dependable lot . . . they have to be, and they like to work with tools of the same caliber . . . which is one reason why the Baker Wall Scraper is, and ALWAYS HAS BEEN a favorite among experienced operators.

The Baker Rotary Wall Scraper provides a safe, economical method of enlarging the walls of an open hole to a diameter considerably larger than that of the casing through which it is run.

SIMPLICITY OF USE AND OPERATION:

This tool is practically fool-proof. It is constructed with a minimum number of essential parts. Any experienced driller can secure FIRST TIME satisfactory results.

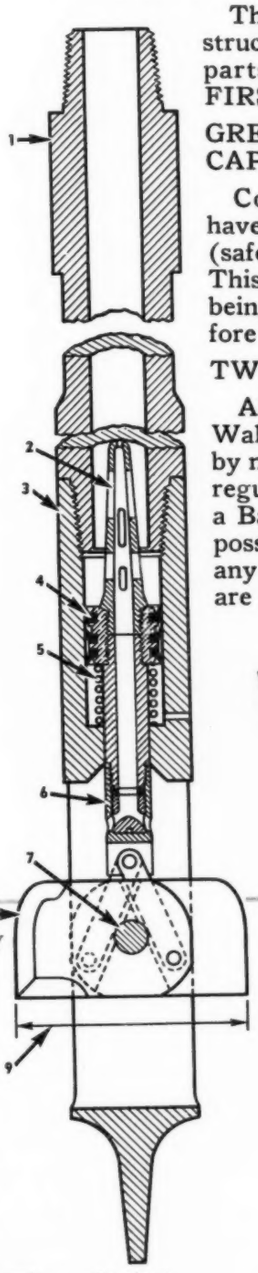
GREAT STRENGTH AND REAMING CAPACITY:

Correct design plus sturdy construction, have combined to give the tool great strength (safety), and a remarkable reaming capacity. This has resulted in the Baker Wall Scraper being able to accomplish many jobs never before considered possible.

TWO TOOLS IN ONE:

Also, don't overlook the fact that the Baker Wall Scraper is really "Two Tools in One", as by merely substituting Sampler Blades for the regular Scraper Blades converts the tool into a Baker Wall Sampler. With this device it is possible to take cores from the side walls of any encased hole at any depth . . . cores that are adequate for accurate laboratory analysis.

Send for Baker Broadcast No. 19 . . . a 40-page illustrated treatise giving complete details as to the many practical field applications for the Baker Wall Scraper and Wall Sampler.



Product No. 500

Baker Rotary Wall Scraper

Features Which Make the *BAKER ROTARY WALL SCRAPER* A DEPENDABLE TOOL:

(1) Double Pin Drill Collar—Connects Wall Scraper Body to drill collar.

(2) Circulation Screen—Design of cone-shaped Screen minimizes abrasive action of fluid and prevents debris from clogging circulation passages.

(3) Wall Scraper Body—Machined out of a solid piece of special alloy steel . . . provides great strength.

(4) Plunger Head—Provided with oil resistant Seals to prevent fluid by-pass and insure Piston efficiency . . . Blades will Positively Open.

(5) Plunger Spring—Strong Plunger Spring insures blades properly closing.

(6) Bushing (Circulation Bean)—Fluid is directed on each blade, lubricating and cooling cutting surfaces.

(7) Hinge Pin—Machined from solid piece of special alloy steel.

(8) Blades—Machined from special alloy steel forgings . . . afford toughness and hardness. Cutting edges are hard-faced and set with Tungsten Carbide Inserts. Long bearing surface on blades minimizes "corkscrewing."

(9) Blade Expansion—Amazing reaming capacity provided by expansion range of Cutter Blades from 4" to 36".

For further instructions and operating details, see pages 279-287 of the 1942 Baker or Composite Catalog.

Service Note

Competent Baker men will service, make suggestions, and otherwise assist in securing best possible results.

MACHINERY and EQUIPMENT

Fog Nozzle for Fire Fighting

GREATLY increased industrial and maritime fire hazards and the possibility of incendiary bombing attacks have stimulated efforts to provide more efficient means of combating fire. A recent product of this search for better fire-fighting methods is the line of "Fogjet" nozzles developed by Spraying Systems Company, 4020 West Lake Street, Chicago, Illinois.

These specialists in spraying nozzle manufacture have designed both a fog

laying and fog throwing type of nozzle. Both nozzles do a thorough job of breaking a water stream into extremely fine particles to produce a fog that is particularly effective in fighting fires involving highly volatile and inflammable material, it is stated. These nozzles greatly increase the exposed surface area of any given volume of water and quenching of almost any type of fire is speedily and efficiently accomplished with a minimum of water damage, it is stated.

The fog laying "Fogjet" nozzle was specifically designed for use in pipe lines and sprinkler systems and comes in various sizes capable of blanketing areas from 12 to 20 ft. in diameter depending on the pressure and size of nozzle.

The fog throwing "Fogjet" nozzle fits any 1½-in. male National Standard Thread hose connection and at 100-lb. pressure is capable of projecting a fog-like mist of uniform distribution to distances of 40-50 ft.

Both nozzles produce a finely-divided, compact fog that, together with the steam formed in the presence of fire, blanket the fire and dilute and cool the volatile material involved.

Unitized Block Assemblies

TWO unitized block assemblies recently developed by the Baash-Ross Tool Company, Los Angeles, California, feature compactness and adaptability to modern portable rig operations. These assemblies combine both the block and hook into one compact, streamlined unit, thus saving much valuable space compared with the separate block-plus-hook arrangement. By decreasing the space required for hook and block, the effective working height of portable rigs is substantially increased. The assemblies permit pipe to be brought out of the hole faster, without risk of running into the crown, greatly speed-up floor operations by the increased working room provided, and also increase the safety and convenience of portable rig operations, the manufacturer asserts.

(Right) BAASH-ROSS UNITIZED BLOCK WITH LINK ADAPTER ASSEMBLY

(Above) BAASH-ROSS UNITIZED BLOCK WITH HOOK ASSEMBLY
(Inset at right shows Hook open with view of Automatic Latch)

Baash-Ross Unitized Blocks are available in two types—either with spring-loaded hook or with spring-loaded link adapter—to meet a wide range of portable well-pulling and slim-hole drilling requirements.

The block with spring loaded hook is similar to the conventional hook-plus-block assembly, but is far more compact due to the elimination of the space normally required for block and hook bails, it is pointed out. The hook is free-swiveling, but when desirable, can be quickly locked in any one of four positions by means of a built-in locking pin.

An automatic latch is provided for locking the hook in closed position—an important safety feature in rough drilling operations—and when open, this latch also acts as a guide for picking up the swivel bail.

Where maximum compactness is desired, the link adapter assembly is recommended. With this assembly the elevator links are supported on ears provided on the side of the link adapter body and are locked in place by bolts. This unit, like the hook unit, is spring-loaded and free swiveling, and can be locked against rotation in any one of four positions by means of a built-in locking pin. It is available with or without a bottom clevis bail for handling rod hooks and similar equipment.

Both block units are completely streamlined with all bolts recessed into the body where they cannot catch on rig projections or clothing. Many other advanced features are incorporated in the design of the Baash-Ross Unitized Block Assemblies to increase their convenience, safety, and efficiency.

Each of the two types of unitized block assemblies is available in nine sizes—a range wide enough to meet the requirements of practically any portable rig job. Each type of block is available in one, two, or three-sheave models (capacities 30, 60, and 100 tons, respectively) and each of these models is available with 20-in., 24-in., or 30-in. sheaves.

Complete information can be obtained by writing direct to Baash-Ross Tool Company, 5512 Boyle Avenue, Los Angeles, California.

High Inertia Generators Designed to Save Copper

HIGH inertia electric generators usually require large diameter rotors, as inertia is proportional to the square of the radius. Large diameter rotors call for large amounts of copper. Confronted with the problem of providing generators of high flywheel effect for an aluminum plant, Westinghouse Electric and Manufacturing Company engineers solved the problem by using extra heavy rotor construction. First it was decided to reduce the rotor diameter, but this normally required a length of 17 in. By adopting the extra heavy rotor it was possible to cut the length to 13½ in. Thus the inertia was obtained with steel and the copper requirements were held to a minimum at the same time. This design saved nearly a thousand pounds of copper on each of eighteen 2250-kw. generators. The machines are driven by Diesel engines and without high-inertia generation the pulsation of the reciprocating engines would be reflected in the voltage. This would have an adverse effect on the electrolytic cells where aluminum is deposited, according to Westinghouse experts.

Hydraulically Controlled Cutting-Off Unit

THE Landis Machine Company, Waynesboro, Pennsylvania, has recently developed a hydraulically controlled cutting-off unit. This device replaces the standard carriage, crossrail, and die head of the Landis Mill Type Pipe Threading Machines when these machines are to be used strictly for the cutting-off operation and when maximum operating efficiency is desired.

The Landis Hydraulically Controlled Cutting-Off Device comprises two high-speed steel cutting-off tools mounted in massive slides for maximum rigidity. These tool slides function through a hydraulic cycle that provides rapid traverse of the tools to the work and rapid retract of the tools after the cutting-off operation is completed. A single lever controls both the forward and return movements of the tool slide.

Complete operator control of the hydraulic cycle provides variable feed rates for the cutting-off tools and adjustment of the length of travel of these tools for different thicknesses of tubing. The adjustment for rate of feed is made through a single control valve so that the rate of feed, for both the front and rear cutting-off tools will be the same. The cutting-off tool slides likewise are adjustable, within certain limits, for various diameters of tubing.

Make 'em last till VICTORY!

THE HIGHER STANDARD

TIME is an ally . . . every extra month, or week, or day of service you squeeze from your equipment is a step toward Victory. Conserve your cable tools in every way possible. Spang Cable-System Drilling and Fishing Tools are BUILT TO ENDURE if you take care of them.

SPANG & COMPANY, Butler, Pa.

SPANG

THE BIGGEST NAME IN CABLE TOOLS

Rubber-Covered Liquid-Level Controller

A COMPLETELY rubber- or neoprene - covered liquid - level controller is available for installation in a standard rubber-covered tee fitting, or for direct mounting in a tank containing corrosive fluids. Rubber-covered steel flexible shaft eliminates packing glands and bearings and also provides a simple friction-free method of transmitting the float motion to an air pilot valve or micro-switch as required, states Moore Products Company, H and Lycoming Streets, Philadelphia, Pennsylvania.

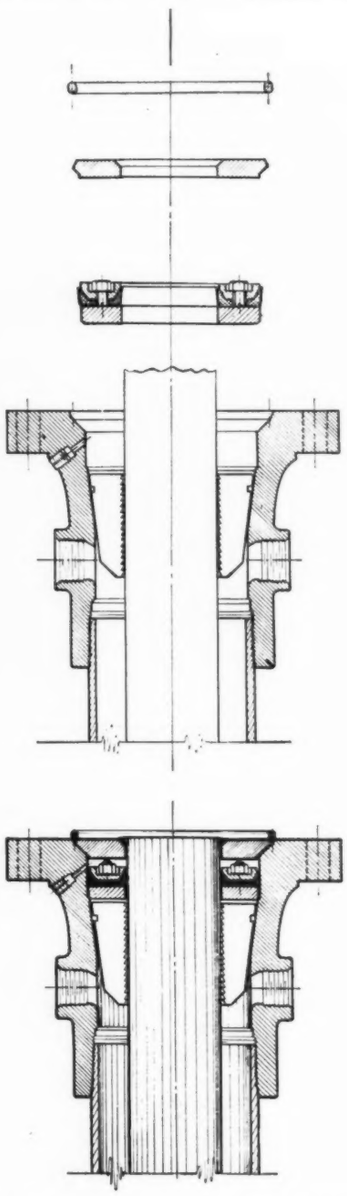
The flexible shaft consists of a formed tube similar to a Bourdon. A flat lever inside this tube connects directly with the air pilot valve or micro-switch for controlling the liquid level. Operation is not affected by wide variations of pressure and temperature.

Operating on the principle of force change due to buoyancy, rather than a float riding on a moving level, sensitivity is such that a buoyancy change of less than 8 oz. will result in full travel of the diaphragm-operated control valve. This permits the use of a small 4-in. diameter ball float and short float arm approximately 5½ in. in length. Interface level control of liquids having a specific gravity difference as small as 0.050 can be obtained by using larger floats and longer float arms.

Elliptical steel floats having ⅛-in. rubber covering are used where wider level changes are desirable. For high and low level cut-off or alarm, a micro-switch can be supplied in place of air pilot valve. Rubber-covered stops are provided to keep the flexible shaft well within its elastic limit.

Rector Weld Test Packoff

RECTOR Well Equipment Company, Fort Worth, Texas, announces a new weld test packoff for



application to "RH" type Rectorheads, which, according to the manufacturer, offers an improvement over previous construction. This packoff, of neoprene-asbestos combination, is an independent

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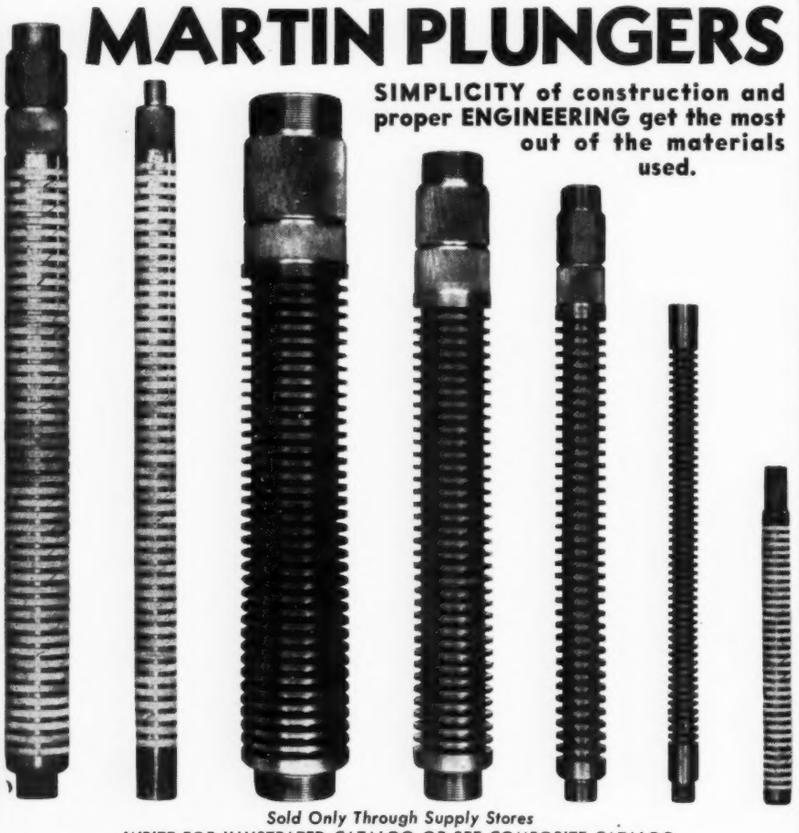
SIMPLICITY of construction and proper ENGINEERING get the most out of the materials used.



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LYNN C. HOLLOWAY, Houston, Texas
J. WALTER WADE, Olney, Ill.
E. C. DILGARDE, Casper, Wyoming

assembly consisting of a lower plate, the packoff material, and a gland that compresses the packing against the body of the head and around the pipe by means of studs.

This assembly rides on a shoulder in the head and does not rest upon the slips.

The method of assembly is illustrated in the accompanying sketch, showing an "RH" type Rectorhead unassembled. The method of use, as offered by the manufacturer, is as follows:

1. Take a stretch in pipe and set slips in the usual manner.
2. Cut off pipe 3 in. above face of body flange.
3. Clean out head thoroughly and apply weld test packoff above slips.
4. Tighten bolts evenly on weld test assembly.
5. Apply welding ring, being sure it rides flush with the face of the flange and level. Use A.P.I. ring for centering.
6. Weld ring to casing, using not less than three beads.
7. Trim casing 1 in. above weld, and bevel.
8. Bolt flange or other piece of equipment to body, with A.P.I. seal ring in place, and test weld by applying pressure through test port.

G-E Electron Microscope

PARTICLES as small as one millionth of an inch—one thousandth the diameter of a human hair—can be measured accurately with a new electron microscope developed by General Electric Company engineers. This was revealed by Dr. C. H. Bachman, of the G-E Electronics Laboratory at Schenectady, New York, in a talk recently to the Lynn, Massachusetts, section of the American Institute of Electrical Engineers.

This is made possible, according to Dr. Bachman, by the use of a new type electron optical system that maintains a "fixed" magnification regardless of voltage variations; previous electron microscopes have suffered in this respect because their magnification varied with the applied voltage.

"With the new G-E electron microscope, small cubical shaped smoke particles only one millionth of an inch, for example, can be clearly seen," the engineer explained.

"In the new instrument, a specimen can be enlarged 10,000 times. Further enlargement of the picture can be made photographically, up to 100,000 times the size of the original specimen, or better. Thus the total enlargement employed depends on how the resulting picture is to be used. If, for example, a picture is to be shown to an audience a larger print is necessary than would be employed in a book. What counts is the resolution, or sharpness, of the picture. The magnification is only a matter of choice or convenience."

IPCO Drum Plug Wrench

THE IPCO plug wrench is designed for removing and tightening plugs or bungs in steel drums; fits all sizes.

It is a time-saving, practical tool that will solve the problem in many departments where all classes of drums are handled, according to the manufacturer.

The wrench is made of steel alloy with long iron pipe handle, also of "S monel" metal, which has low sparking qualities.

Further details may be had by writing to Industrial Products Company, 2820 North Fourth Street, Philadelphia, Pennsylvania.

Success in battle takes both fighting power and protection from the enemy. Case Oilfield Engines give eager, aggressive power. They have exceptional protection against dust and dirt, extremes of temperature, and against perils to lubrication. Combined with sturdy construction, these qualities spell ENDURANCE.

Coming from extra care with countless engineering details, this endurance permits amazingly long periods of continuous operation with little attendant labor. Maintenance intervals are long, shutdown time is short, and renewal operations are adapted to service in the field. It brings steadier working of wells, better use of pipe-line capacity, helps to win the battle of oil.

These engines are available to operators who need them for work essential to the war effort. If you have such need, or will have, consult your Case distributor now. J. I. Case Co., Racine, Wis.

SOUTHWEST EQUIPMENT COMPANY
Dallas and Kilgore, Texas

LELAND EQUIPMENT COMPANY
Tulsa, Oklahoma

ALLIED SUPPLY COMPANY
Los Angeles, Calif.

CASE

Since 1842 IN PEACE AND WAR

Air-Driven Mixers

MIXING Equipment Company, Rochester, New York, announces the addition to their regular line of three new heavy-duty air-driven mixers. Two of them are gear reduction models. The third is a larger direct-drive model.

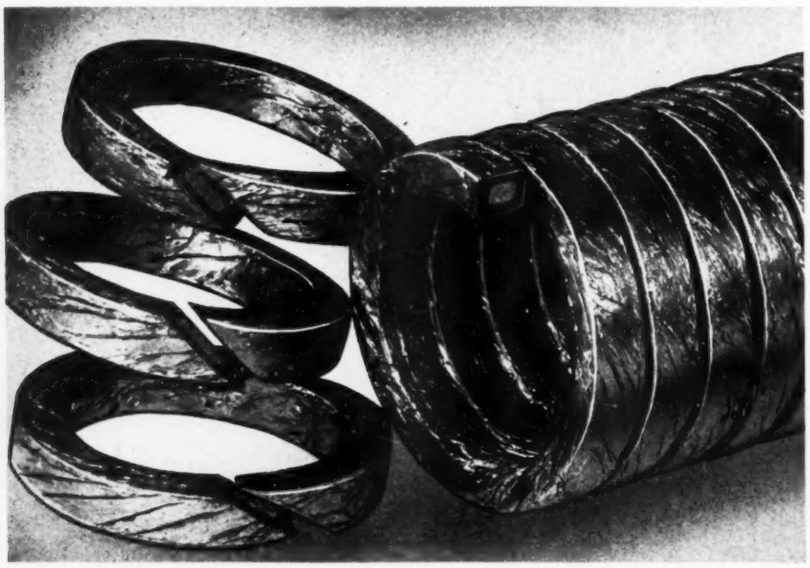
The important features of these mixers especially adapt them to the mixing of paints, chemicals, high explosives, and alcoholic compounds, the manufacturer asserts. The air-driven motors used in these mixers cannot be overloaded or burned out, it is stated. Even when used in the heaviest liquids they will not stall. The air exhaust from the motor is so arranged that it keeps the motor running cool at all times.

Models of 1 hp. and ⅓ hp. are available. They are equipped with gear reduction drive and adjustable shaft length.

TABLE OF SPECIFICATIONS

	Model AG-33	*Model AG-100*	*Model AR-100*
Top motor speed	1800	1800	1800
Top mixer shaft speed	400	431	1800
Size of propeller	8 in.	12 in.	5 in.
Number of propellers	2	2	2
Maximum shaft length	60 in.	60 in.	48 in.
Shaft diameter	⅞ in.	⅞ in.	⅝ in.
Approximate weight	48 lb.	50 lb.	35 lb.

Shaft and propeller materials: Stainless, plain steel, monel, bronze, etc.



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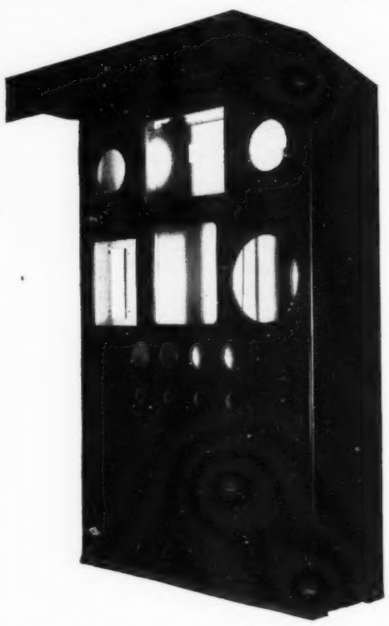
Manufactured in Canada by JOSEPH ROBB & CO., LTD., Montreal

Masonite in Instrument and Control Panels

IN STEP with the effort to conserve sheet steel so vital to war needs The Hays Corporation, Michigan City, Indiana, announces instrument and control panels made of Masonite reinforced with steel angles. The body of the panel



is made of cross-grained Masonite ⅝ in. thick bolted to a framework of 3 by 3 angle steel. Braces of 2 by 2 angle steel reinforce the center of the panel to insure adequate support for the instruments and controllers. The canopy and doors are of cross-grained Masonite 5/16 in. thick.

Masonite material is exceedingly hard and takes a finish comparable to steel.

A. R. Abelt Director Chain Belt

At a recent meeting of the board of directors of Chain Belt Company, A. R. Abelt, secretary of the company, was elected a director to replace F. J. Weschler of the Baldwin-Duckworth Division who died last month. In addition to being made a director of the company, Abelt was also elected a vice-president.

A. R. Abelt joined the Chain Belt organization in 1907 as a very young man

A. R. ABELT

and literally grew up with the company. He has served it in many capacities, which have included production, sales, and executive work. In 1922 he was made sales manager of the Chain Belt and Transmission Division, a position he retained until early in 1942 when he became manager of that division. He has been secretary of the company since 1930.

G. D. Gilbert, sales manager of the Baldwin-Duckworth Division of the company, at Springfield, Massachusetts, has been made general manager of that division and also elected secretary of the company to succeed Abelt. Gilbert entered the employ of the Duckworth Chain and Manufacturing Company in 1918. He was made sales manager of that company in 1924 and was successively sales manager of the Baldwin-Duckworth Chain Corporation and the Baldwin-Duckworth Division of Chain Belt Company created by a merger of Baldwin-Duckworth and Chain Belt in 1939. He is also a director of Chain Belt Company.

Key Company Opens District Offices

Key Company has opened a district office at 1315 Second National Bank Building, Houston, Texas, with J. H. (Jim) Richardson as district manager.

The Tulsa, Oklahoma, office will be at 533 Mayo Building, Tulsa, Oklahoma, with M. J. (Max) Masel as district manager.

Key Company was formerly represented in the Southwest by the Koalt Engineering Company of Tulsa, Oklahoma.

Lieut. Blaine Cole Killed in Action

At the Axelson Manufacturing Company in Los Angeles, a blue star was replaced in the company's big service flag by a gold star honoring Lieutenant Blaine Cole.

Lieutenant Cole, former engineer for Axelson, was the first man from Los Angeles to give his life for his country in the Allied invasion of North Africa. As an officer engineer in the amphibious forces, he was reported to have been killed in the landing at Casablanca.

Cole was well known to men of the oil industry. He was with the Gulf Oil Corporation in Houston for several years before he joined Axelson. Blaine was born in Kanasas City, graduated from the University of Missouri, and devoted the better share of his engineering life to the construction, drilling, and production problems of the petroleum industry.

HILL-HUBBELL
STEEL PIPE PROTECTION
PLAYS AN IMPORTANT PART

"PASS THE AMMUNITION" is not limited to shells. Oil and gas are vital to the manufacture of war material. Shatter-proof, underground steel pipe lines are necessary for trouble-free transmission of these home front ammunitions.

HILL-HUBBELL STEEL PIPE PROTECTION is recognized by leading pipe line engineers as the standard.

Since HILL-HUBBELL factory processed steel pipe requires less time to install, pipe lines get into service quicker and at no greater cost.

A request on your letterhead will bring a copy of *The Book of Pipe Protection*, which describes our process in detail.

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Tells of Experiences in Nazi Concentration Camps

The experiences of a man who has twice been in a Nazi concentration camp were told at the regular monthly meeting of the Los Angeles Chapter of Nomads held in Los Angeles in December. Preceding the dinner a short business session was held at which the nominating committee selected to nominate chapter officers and regents for the coming year presented its report. After the list of nominees was read, other nominations were made from the floor. The officers will be voted upon by ballot before the annual meeting in January at which time the result of the voting will be announced.

The speaker of the evening was Dr. Kenneth Walker, philosopher, lecturer, musician, author, and Nazi prisoner. He told of his three interviews with Hitler, one of which took place in the secret retreat back of Berchtesgarten. These interviews led to his arrest by the Gestapo and internment in Nuremberg

Left to right: R. W. McCool, Ernest H. Smith, Kenneth Walker, and M. H. Hobbs

prison. After once being released from prison he spent some time in America and European countries and then went back to Germany. This ended in another arrest and confinement at Nuremberg. Dr. Walker told of some of his experiences while in prison. He has also lived a number of years in Italy and after his talk answered questions about the conditions in that country.

Among the guests present at the meeting, which was the largest for several months, were the following men from other countries: Ernest H. Smith of California Arabian Standard Oil Company; Bob McCool of Trinidad Leaseholds, Ltd.; M. H. Hobbs of Nederlandsche Koloniale Petroleum Maatschappij, and J. C. B. Vandenberg of Bataafsche Petroleum Mattschappij.

G.E. Plans New Series of Welding Films

Joe McGee, the Welder, the saucy cartoon personality who made a host of friends when introduced last summer in General Electric's popular industrial training films, "The Inside of Arc Welding," will play a return engagement in the spring in a new series of training motion pictures on welding, "The Inside of Atomic Hydrogen Welding," which is now in preparation at the Raphael G. Wolff Studios in Hollywood under General Electric sponsorship.

The new training program will be similar in idea and treatment to the preceding series. It is being produced by the same studio that produced "The Inside of Arc Welding" in 16mm

Kodachrome, and will employ photographic, animated diagram, and cartoon techniques.

"The Inside of Arc Welding" has, to date, been actively used in the training programs of more than 2000 war production plants and army and navy depots and has been widely praised for its effectiveness in presenting the subject. "The Inside of Atomic Hydrogen Welding," it is expected, will be available for manufacturing plants, schools, and other training centers about March 15.

Army-Navy "E" to Johns-Manville Plant

Teamwork by government and business, which is winning many battles of production under the lash of war, could be just as effective in helping to win the peace after war is won, Lewis H. Brown, president of Johns-Manville, declared recently at ceremonies in which the Army-Navy "E" award was presented to employees of the Kansas Ordnance Plant, built and operated by J-M Service Corporation, a Johns-Manville subsidiary.

Brown said that "I have developed a deep appreciation of the fact that only through the type of real coöperation given to industry by the Ordnance Department are such achievements as we are celebrating today made possible."

Brown referred to a recent statement made by Major General Levin H. Campbell, Jr., in which the Chief of Ordnance said "that the best way to get production results is to turn business men loose, wherever possible, on the jobs they know best."

The speaker said he quoted this statement "not because I think it is a pat on the back for business men, I quote it because it expresses a point of view that, to me, can be vitally significant, not only in winning this war but also in winning the peace after the war is won.

"It seems to me unfortunate that more people in government do not recognize the simple fact that we cannot make real progress as long as there is basic conflict between government and business," Brown said. "There should be no real conflict. And as we continue to work side by side in our united efforts to win this war the shortsightedness of those who would encourage such conflict becomes more and more apparent."

"I hope that you can all see with me, and believe with me, that no job is too hard, no goal too distant for a free American people, if the power of our government can be teamed in time of peace with the tremendous resources and genius of American industry."

E. C. Fink, Mack Truck President, Dies at 62

E. C. Fink, president and chairman of the board of Mack Trucks, Inc., died in New York City on January 1 as the result of a heart attack suffered a few days earlier. He was 62 years old.

A pioneer in the truck industry, Fink had been an officer of the company since its organization in 1911 following a consolidation of the Mack Brothers Motor Car Company, the Hewitt Motor Company, and the Sauer Motor Truck Company. He was for many years vice-president in charge of production at the company's plants in Allentown, Pennsylvania, Plainfield, New Jersey, and New Brunswick, New Jersey. Fink was elected president and chairman of the board in January, 1937, succeeding the late Charles Hayden.

Born in Cincinnati, Ohio, Fink began his career with the old machine tool firm of Lodge and Shipley. He later served with the Prentiss Tool and Supply Company, and the Stevens Arms Interests.

He is survived by his widow, Mrs. Clara Fink; a daughter, Mrs. H. Fillis, and a sister, Mrs. A. G. Sherman.

Drops Faster
PULLS MORE FLUID—
MORE IMPORTANT
TODAY THAN
EVER BEFORE!
THE GUIBERSON SWAB
Proved in peace, the basic advantages of the GUIBERSON SWAB are emphasized in war . . . Because of its exclusive, patented design, this time-tried stand-by of the producer falls faster and pulls more fluid per trip and per cup life than any other swab ever made . . . Thus does it meet the first requirement of wartime operation—maximum results with a minimum expenditure of time, labor and materials . . . One of a comprehensive line of practical specialties described in the Composite Catalog...Details on request.
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MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

R. W. Gallagher New President Standard Oil Company

R. W. Gallagher, chairman of the board, has been elected president and chief executive officer of the Standard Oil Company (N. J.) to fill the vacancy created by the death of W. S. Farish on November 29, 1942. The post of chairman will not be filled. Eugene Holman, a vice-president and member of the board, was elected to membership in the executive committee.

Gallagher, long recognized in the company and throughout the oil industry for his qualities of progressive leadership, was president of the East Ohio Gas Company when he was elected to the board of Standard Oil Company (N. J.) in 1933. He became a vice-president in 1937, and last November succeeded W. C. Teagle as chairman.

Born in Salamanca, New York, in 1881, Gallagher was forced by his father's illness to leave high school at the age of 16 to take a job with the New York Transit Company. He completed his high school studies by working at night, and with the help of his mother continued with home-study of college courses and engineering books. In 1900 he went to Akron as shop foreman for the East Ohio Gas Company. After becoming successively general foreman, paymaster, and superintendent of pipe lines he became president of that company in 1926.

Gallagher lives at Shippan Point, Stamford, Connecticut.

Holman, born in San Angelo, Texas, in 1895, specialized in geology at the University of Texas. He served in the U. S. Army in the World War and took a job with the Humble Oil and Refining Company in 1919 upon his return from France. In 1923 he was made superintendent of the North Louisiana and Arkansas division of Humble, and two years later was advanced to the post of chief geologist. He went to New York in 1929 as assistant to vice-president E. J. Sadler of the Standard Oil Company (N. J.), later serving as president of the Creole Petroleum Corporation and Lago Petroleum Corporation. He was elected to the board of the Standard Oil Company (N. J.) in 1940 and became a vice-president last year.

Goodrich Technical Men to Government Posts

Three more B. F. Goodrich Company technical men have been loaned to the United States government and will assume posts in organizations administrating the nation's synthetic rubber program, it is announced by T. G. Graham, B. F. Goodrich vice-president.

W. R. Hucks, manager of the raw materials division of the company, will be assigned to the operating division of the Rubber Reserve Company. He joined B. F. Goodrich in 1926 as a compounder in the tire division, went to the California plant in 1928 as chief chemist, later becoming technical manager of the Pacific division. He returned to Akron in 1938 to take over his present work. Hucks is a graduate of Georgia Tech.

R. G. Boyd, now manager of planning and scheduling in the tire division, has been assigned to the allocation division of the War Production Board. He joined B. F. Goodrich in 1927 shortly after his graduation from the United States Naval Academy. After several years in the technical service division he was assigned to foreign service by the company, returning to Akron from France in 1939.

R. J. Hull, who will serve on the staff of the Rubber Administrator, is assistant manager of compounding in the company's tire division. He joined the Goodrich staff in 1927 after graduating from Purdue University. After experience in the company's general chemical laboratories he was transferred to the tire division as a compounder.

Licking the American Accident Plague

The National Safety Council is making progress tracking down the spectre of manpower losses through accidental death and injury hanging over war production lines. Latest and biggest counter-move in what is shaping up as a national safety movement is a grass-roots drive on accidents planned for 14 major war production centers.

For the last several months the Council has been feeling out the national accident situation. A network of liaison with government agencies, with private industry, and more than a hundred private organizations has been set up; and now, with the decks cleared for action, and armed by voluntary contributions through the War Production Fund to Conserve Manpower, the National Safety Council is in a position to go to town in a big way.

William A. Irvin, national chairman of the fund and former steel executive who has emerged as the Nation's spokesman for safety in America, will visit areas hampered by accidents in turning out the tools of war with maximum efficiency. He will be accompanied by Colonel John Stilwell, president of the National Safety Council, and other representatives of that organization.

Local safety leadership will be enlisted among businessmen, industrialists, union heads, and the municipal authorities in each center visited. Each city will be offered the full aid of the National Safety Council in curbing its accident toll. The aim is to make a double-barreled attack on accidents. The council will serve as consultant and overall coördinator. The community will organize and get to work to route out accidents on the spot where they occur.

The five-weeks' swing around the country began January 17 from New York. It will include stops at St. Louis, Chicago, Minneapolis, St. Paul, Seattle, Portland, San Francisco, Los Angeles, San Diego, Fort Worth, Houston, New Orleans, and another city to be designated.

In cities where there are local safety councils, they will be asked to enlist as charter members in the National Safety Council's revised wartime organization. This will provide a permanent framework for a nation-community plan of action. Where no local safety council exists, committees are to be organized that in time can develop into full-fledged safety councils in their own right.

Once community leaders have accepted responsibility for safety within their war production area, the community drive will get under way.

Intensive community drives will be organized at once to get the continuing program off to a flying start. Industrial management will be asked to coöperate in stepped-up safety instruction courses. The police department will be asked to enforce to the letter ordinances covering traffic and pedestrians. Traffic court judges will be asked to use every opportunity to explain the consequences of flouting public safety in wartime.

The school superintendent and the teachers will be asked to stir up lasting concern for the safety of children, on which hangs the morale of war worker families. Children, as well as citizen volunteers—perhaps block wardens—may be given home hazard check lists to take into the home for careful filling out. Safety for women, women war worker fashions and safety devices and the hazards of the unprotected war worker home will be dramatized for the benefit of 4,000,000 women to be recruited in war industry in 1943.

Once it gets under way, to keep community safety at a high pitch it is planned to have monthly safety meetings of management-labor committees. Regular safety meetings may be scheduled for foremen and workmen, especially in the smaller plants where accident-prevention inclines to laxity. Special plant protection measures may be worked out by community safety leaders with the representatives of the OCD, the FBI, and the War Department.

EVERY single day almost four million Elastic Stop Nuts go into war production.

Even at that, and with all our expanded plant, it doesn't fill the demand.

It happens that the most urgent need right now is on aircraft. Every American plane that takes the air has some important part of its structure fastened with these strong, tight-holding nuts. Some types take as many as 35,000 in a single ship.

The reason is: *these nuts stay put under the toughest circumstances.*

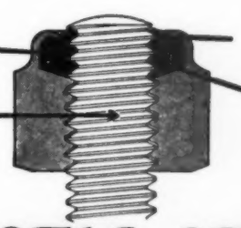
You handle them exactly like regular nuts. They go on fast, lock immediately and automatically.

There's no need of pins, washers or auxiliary locking devices.

Once on, they stay there — never shake loose. But you can take them off and put them back on many times and they won't lose their locking ability.

This is why there are more Elastic Stop Nuts on America's planes than all other lock nuts combined. And why they are also used in important structural applications on guns, naval vessels and other war equipment.

We have made billions of Elastic Stop Nuts and, as far as we know, not one has ever loosened.


Tough, elastic locking element.
Fits standard bolt.
Seals threads at top — prevents corrosion of working threads.
Locking collar cannot harm the bolt threads.

● Write for folder explaining the Elastic Stop self-locking principle.

ELASTIC STOP

SELF-LOCKING NUTS AND AIRCRAFT FITTINGS

ELASTIC STOP NUT CORPORATION

2330 Vauxhall Road, Union, N. J.

Fluor Opens New York Office

In a move that provides direct company representation on the Atlantic Seaboard, The Fluor Corporation, Ltd., announces the opening of a direct company branch office in New York City at 1919 R.C.A. Building, 30 Rockefeller Plaza, with J. I. Lawrence, formerly of the company's Kansas City office, in charge.

The new office is staffed and equipped to handle all matters pertaining to the sale of Fluor Atmospheric Aerator and Mechanical Draft Cooling Towers, Fluor Gas Cleaners, and Fluor Mufflers and direct company-customer contact on matters pertaining to the design, engineering and construction of synthetic rubber, toluene, aviation gasoline, alkylation, isomerization, cycling, natural gasoline and gas transmission plants, and refineries in this area.

W. C. Carter President Link-Belt Company

Link-Belt Company, Chicago, Illinois, announces that William C. Carter, for 14 years vice-president and for the last year executive vice-president, has been elected president to succeed Alfred Kauffmann, who has resigned because of ill health.

Carter, a mechanical engineering graduate of the University of Illinois, joined the Link-Belt Pershing Road Chi-

WILLIAM C. CARTER

cago plant organization in 1902 as a draftsman. He has consecutively held the positions of engineering department supervisor, construction superintendent, plant superintendent, plant general manager, and vice-president in charge of production. He has been executive vice-president in complete charge of company affairs since Kauffmann's illness.

Kauffmann, who has so ably served the company for 41 years, rising from draftsman in 1901 to president in 1924, is retiring from active service in order to recover his health. He remains a member of the Board.

In tendering his resignation, his comment was—"After having given the company 41 years of service, I feel that I have earned a release from the exacting duties of chief executive."

Carter's headquarters will continue to be 307 North Michigan, Chicago, Illinois.

Philgas Division of Phillips Moves Headquarters

The general offices of Philgas Division, Phillips Petroleum Company, have been moved from the General Motors Building, Detroit, Michigan, to Phillips' principal operating offices at Bartlesville, Oklahoma.

"The new location will permit closer correlation of policy and operating problems, which is necessary under war conditions," said Frank Phillips, chairman, and K. S. Adams, president of Phillips Petroleum Company, in announcing the move. "So far as the move affects our customers and suppliers, it is merely a change of mailing address. Essentially the same key personnel will be at the new location, and no changes in operating methods are involved."

INSTANT POWER . . . always ready . . . for INDUSTRIES, NATIONAL DEFENSE, OIL FIELD PRODUCTION whenever and wherever needed. Dependable electric power will handle jobs of all sizes with equal facility and minimum expense. Complete information for your own individual needs may be obtained through our oil field offices in Gladewater, Henderson, Kilgore, Longview and Shreveport.

SOUTHWESTERN GAS & ELECTRIC COMPANY

DeLorenzo Appointed by Brown Fintube Company

The Brown Fintube Company, Elyria, Ohio, manufacturers of resistance welded integrally bonded fintubes, and heat exchangers, has announced the appointment of B. DeLorenzo to be manager of the Heat Transfer Department.

B. DeLORENZO

DeLorenzo graduated from the Massachusetts Institute of Technology in chemical engineering in 1930, and then spent an additional two years there in graduate study and research. He joined the Foster Wheeler Corporation, New York, as laboratory technician in 1932, working on solvent refining of petroleum products, and since 1936 had been design engineer for Foster Wheeler in the oil division, specializing on heat transfers and flows of fluids.

Named on Investigating Committee

John H. Romann, chief metallurgist of Tube Turns, Louisville, Kentucky, manufacturers of welding fittings and special forgings, was recently honored by being appointed chairman of a committee to conduct a special nation-wide investigation in industrial plants concerning the low temperature properties of metals. This research is being carried on for the War Department by the War Metallurgy Committee of the National Research Council, National Academy of Sciences, Washington, D. C.

JOHN H. ROMANN

According to Clyde Williams, head of the War Metallurgy Committee, Romann has been granted an indefinite leave of absence from Tube Turns in order to direct this work.

The War Metallurgy Committee supervises research for several branches of the government, including the War Department. It reports to the Office of Scientific Research and Development, an independent agency created by the President of the United States.

Pomona Pump Company Sold

Charles E. Moore, president of Joshua Hendy Iron Works, Sunnyvale, California, has announced the purchase of the Pomona Pump Company of Pomona, California, and its recently acquired subsidiary, the Westco Pump Division, St. Louis, Missouri. Hendy also purchased the plant and equipment of the Hydril Company, Torrance, California, to supplement the facilities at Pomona.

NIXON *Surface Control*
GAS-LIFT SYSTEM
assures

PROFITABLE PRODUCTION

So extensive are the economies of the Nixon Gas-Lift, that savings on production begin with its installation.

Cost of the Nixon Gas-Lift; Cost of transportation and installation; Cost of operation and maintenance ... are but a fraction of the cost of conventional pumping units.

Production is surface controlled. Large or small volumes handled by this system.

Hundreds of installations have proven its economy and efficiency. Ask a Nixon Gas-Lift engineer to show you case histories of "Profitable Production" with the Nixon Surface Control Gas-Lift System. Write your nearest Wilson Supply Co., store or sales office.

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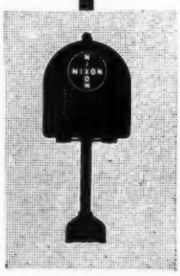

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TRINIDAD, B.W.I.: Neal Massey Engineering Corporation

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TEXAS—Gladewater, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi.
LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport.

Priorities Regulation No. 1 Amended

Priorities Regulation No. 1, the basic document that governs the operations of the priority system, has been amended in several important respects, the Office of Production Management announces.

Most important of the changes is a requirement that *all* orders bearing a priority rating including B-ratings for essential civilian orders as well as A-ratings for defense orders, must be accepted by producers, in preference to any unrated order. Previously the acceptance of B-rated orders was not mandatory.

The required acceptance of B-rated orders is a further transitional step in the move toward allocation of scarce materials, as B ratings are one method of designating the relative importance of civilian uses for materials after war requirements have been met.

Treatment that must be given to defense orders is clarified by a new provision that assigns a priority rating of A-10 to all defense orders not otherwise rated. This change is intended to eliminate any confusion that might arise regarding the handling of those defense orders that were previously unrated, in relation to other orders that had been specifically rated A-10, the lowest rating in the A series.

Section 944.14 of Priorities Regulation No. 1 has been revised to provide a stricter limitation of inventories. Whereas producers were previously forbidden to increase their inventories beyond the amount necessary to meet required deliveries of their products, they are now forbidden to accept delivery of materials for inventory in excess of a practicable working minimum. This means that all inventories of any materials whatever must be reduced to a practicable working minimum, strictly construed, before they can be replenished. The prohibition applies to suppliers of materials for inventory as well as to producers who maintain inventories, and it covers non-defense as well as defense producers. An exception is made, however, for inventories of materials imported from foreign countries.

A possible loophole in the inventory restriction is closed by a provision that no material may be fabricated, processed, alloyed, or otherwise altered if the producer's inventory of the material in its altered form would thereby be increased beyond a practicable working minimum, unless specific authorization is granted by the Director of Priorities.

Another amendment will help to prevent receipt of a new, high-rated order from interfering with fulfillment of the delivery date on a previously accepted lower-rated order. Unless the new order bears an AA rating or is accompanied by specific direction from the Director of Priorities, it will not have to be accepted if its acceptance would necessitate preempting material that has already been completed to fill a previously accepted defense order that bears a lower rating, or if it would preempt material that is within 15 days of completion. Or, if the new order is accepted, the producer may not divert material already completed or about to be completed on a previous defense order for use in filling the new order.

Priorities Regulation No. 1 lays down a general framework for priorities compliance, and it may affect all types of industrial and commercial transactions. Copies of the regulation as amended may be obtained from the Priorities Division of OPM in Washington or from field representatives.

A summary of the important changes, with explanation, is given below:

944.1a. All defense orders, as defined, are assigned an A-10 rating. The Regulation as previously written required the acceptance of defense orders and preferred treatment for such orders, but did not specifically assign them a grade, so that the question was frequently raised as to how unrated defense orders should be treated, in comparison with orders specifically rated A-10. The change is largely one of form rather than substance, because the answer that has been given to this inquiry is that they should be rated as A-10 orders.

944.2. This paragraph has been changed to require acceptance of B rated orders as well as defense orders. As the assignment of a B rating is one form of allocation of scarce material, it is essential that the acceptance of such orders be required, in preference to unrated orders if the allocation is to be effective. The same considerations that led to the adoption of the original provision of the Regulation requiring acceptance of defense orders led to the conclusion that all rated orders should now be made mandatory both as to acceptance and preferred treatment.

944.4. It is provided that any preference rating (including B ratings) may be assigned to any order before the contract or purchase order is placed. This is done in order to provide for identification of prospective purchase orders as to which acceptance is required pursuant to the amendment just discussed.

944.7. Paragraph (b) is amended so that where preference ratings and delivery dates are the same the sequence of deliveries is to be determined by the dates of receipt of the preference rating. At the present time such cases of conflict are to be referred to the Division of Priorities. It is believed that the proper rule is incorporated in the amendment, rather than allowing the date of receipt of the order to govern, as the preference rating is only effective when received.

944.8. The amendment requires that each order bear a specific delivery date. This is done in order to terminate the practice which now exists, particularly in the PD-3 field, of specifying "immediately" as the delivery date.

944.10. This paragraph is revised to make it clear that allocation and limitation orders take precedence over preference ratings and that, generally speaking, the more stringent restrictions take precedence over the less stringent.

944.14. The general inventory restriction is revised in accordance with the policy of the Priorities Division. Hereafter no material may be fabricated, processed, alloyed, or otherwise altered if the producer's inventory of the material in its altered form would thereby be increased beyond a practicable working minimum, unless specific authorization is granted by the Director of Priorities.

944.15. The Regulation as originally drawn required all persons "affected by any rule, regulation or order" to keep records. This rule was difficult of application, as almost any person could be said to be affected by some order or regulation of the Director of Priorities. The revised provision substitutes a rule which seems to be simpler of application, viz. only the persons actually participating in any regulated transaction are required to keep records.

944.18. The original violations provision was restricted to penalties for furnishing false information. It has been expanded so that it now includes penalties for violation of any order or regulation.

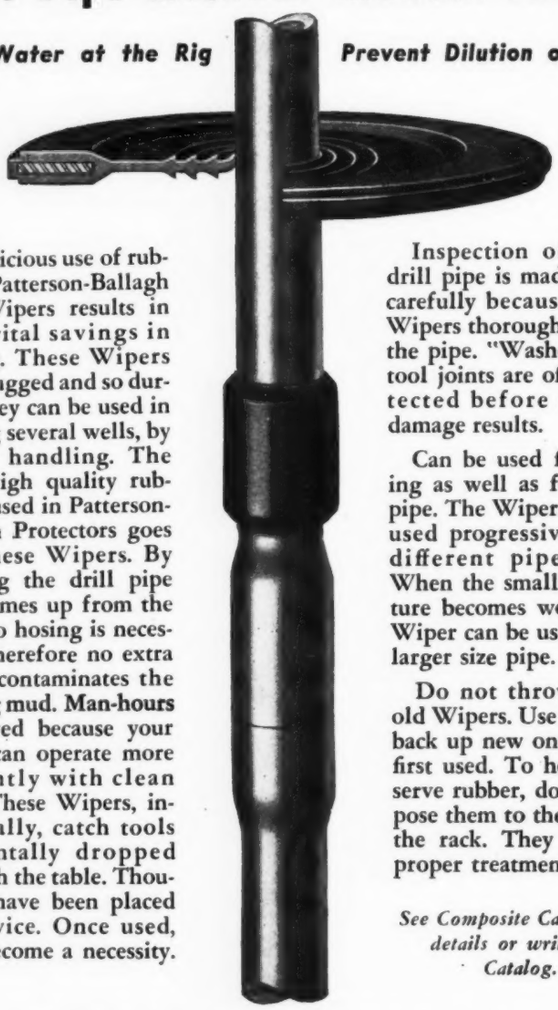
Petroleum Industry Given Higher Preference Ratings

Higher preference ratings on the delivery of materials required for the production, transportation, refining, or marketing of petroleum have been assigned by the War Production Board under provisions of Preference Rating Order P-98-b, as amended on the recommendation of the Petroleum Administrator for War.

The higher preference ratings will speed up

Wipe Pipe Without Manual Effort

Save Water at the Rig ***Prevent Dilution of Mud***



The judicious use of rubber in Patterson-Ballagh Pipe Wipers results in many vital savings in drilling. These Wipers are so rugged and so durable, they can be used in drilling several wells, by proper handling. The same high quality rubber as used in Patterson-Ballagh Protectors goes into these Wipers. By cleaning the drill pipe as it comes up from the well, no hosing is necessary; therefore no extra water contaminates the drilling mud. Man-hours are saved because your crews can operate more efficiently with clean pipe. These Wipers, incidentally, catch tools accidentally dropped through the table. Thousands have been placed in service. Once used, they become a necessity.

Inspection of your drill pipe is made more carefully because these Wipers thoroughly strip the pipe. "Washed out" tool joints are often detected before serious damage results.

Can be used for tubing as well as for drill pipe. The Wipers can be used progressively for different pipe sizes. When the smaller aperture becomes worn, the Wiper can be used for a larger size pipe.

Do not throw away old Wipers. Use them to back up new ones when first used. To help conserve rubber, do not expose them to the sun on the rack. They deserve proper treatment.

See Composite Catalog for details or write for Catalog.

PATTERSON-BALLAGH PIPE WIPERS—TUBING WIPERS

PATTERSON-BALLAGH CORP.

Los Angeles **Houston** **New York City**

the acquisition by petroleum operators of materials necessary to the maintenance of efficient wartime production of petroleum and petroleum products, according to Petroleum Administrator Ickes.

Preference ratings of A-2, A-1-a, or AA-2x now apply on the delivery of materials required for completing alterations involving the use of additional materials valued at $500 or less, for materials required exclusively for research investigations with currently available research facilities, for materials necessary for repair, maintenance, and operating supply purposes, and for materials to be used in any operation directly incident to the discovery, development, or depletion of petroleum pools.

The new preference ratings do not apply to the acquisition of materials:

1. Otherwise obtainable on the date required.
2. The use of which can be eliminated through substitution of less scarce materials or by changes of design that will not seriously reduce operating efficiency.
3. In excess of a 90-day supply.
4. Restricted or prohibited by other orders or regulations of the War Production Board or of equivalent authority in the Dominion of Canada.

Applications of preference ratings under P-98-b must be certified by a duly authorized official of the petroleum operator for each contract or purchase order.

In certain instances, prior approval of application of preference ratings must be obtained from the Director General for Operations. Some certifications will require the countersignature of District Directors of Materials for the Petroleum Administration for War.

Advance approval of preference ratings shall be obtained through the Petroleum Administrator for War, according to Robert E. Allen, Acting Deputy Petroleum Administrator. He said:

"This assistance will be given with all possible speed, as will the required countersignatures required of District Directors of Materials, in order to implement fully the purposes of the new preference ratings."

Preference Rating Order P-98-b will remain in effect until revoked.

Executive Order 9240—Overtime Compensation

The following interpretations of Executive Order 9240, modify somewhat the information in Administrative Bulletin 42-40. These interpretations are informal and although based on information from the Department of Labor may not be final. The questions have been presented to the Department in writing for a written ruling.

A number of oil companies have received letters or telegrams similar to the following, ruling that the order applies even to drilling operations:

"It would appear that employers engaged in drilling for, and in the production of, petroleum are within the coverage of the Executive Order without regard as to whether they are prime contractors or subcontractors with the Federal Government. It is fair to assume that such oil is necessary and is utilized for the completion of contracts which manufacturing establishments have for the furnishing of war products." (A hearing on this Order is to be held in Washington, D. C., January 19 at 10:30 a. m.)

Pumpers on stripper wells are covered if their salary is dependent on the number of hours worked, but they may be considered exempt if they are not paid by the hour or day. The nature of their pay is the determining factor. This applies to all salaried employees where the salary is based on a fixed period, such as a month, without regard to the hours actually worked. This ruling is akin to the ruling on administrative employees under Wage Hour. Administrative employees do not come under the order.

Distributing is not considered under the order unless it is done by a company that also processes materials. Under this ruling it appears that jobbers and independent service station operators are not covered while the bulk plants and stations of major oil companies are. The same ruling has been applied to pipe lines. Employees of common carriers are not covered, others are if the company owning the line is also a "producer" of goods.

A number of rulings have been received by companies substantially as follows:

"If you have arranged with your employees for a mutually satisfactory work schedule providing one day of rest in each regularly scheduled work week, I am of the opinion that double time need not be paid for the seventh day. A regular work week under Order 9240 would be seven successive days starting on the same calendar day each week."

Inquiring as to what would amount to a "mutually satisfactory work schedule", we were informed that although a collective bargaining agreement is not necessary, some notice must be given employees that they are entitled to double time for the seventh consecutive day and they must agree to continue to work the same work week schedules without the premium pay. It was suggested that a notice might be posted to the above effect and that if no protest was received they would be considered to have accepted the prevailing work schedules as satisfactory.

A number of industries have been granted exemptions from the Executive Order by the Secretary of Labor.

Permissible Spacing Patterns Defined

The Petroleum Administration for War has issued Petroleum Administration Order No. 2, which defines permissible spacing patterns for oil wells drilled in Illinois and portions of Indiana and Kentucky.

The order includes, without change, all the provisions formerly embodied in WPB Conservation Order M-68-5. It will remain effective until February 1, 1943, unless sooner revoked.

Issuance of these well-spacing provisions in a Petroleum Administration Order follow the WPB's action on January 4, when it authorized the Petroleum Administration to extend, amend, modify, or revoke all orders in the M-68 series.

Oil-Pumping Units Removed From M-126

Oil-well pumping units have been removed from the list of items in which the use of steel is prohibited by Conservation Order M-126 as amended December 5 by the Director General for Operations.

This action was taken on the suggestion of the Petroleum Administrator for War. The units, essential in the production of oil, must be made of either steel or high-grade wood. Manufacturers have been unable to obtain the type of lumber required.

Approves War Bond Purchase Plan

Petroleum Administrator for War Harold L. Ickes has expressed himself as being heartily in accord with the Petroleum Industry War Council's recent recommendation urging all oil companies to adopt a 10 percent payroll savings plan to buy War Bonds.

Calling attention to the Council's resolution, which endorses an industry-wide 10 percent War Bond drive and urges all companies to take every possible step to bring the Payroll Savings Plan to 10 percent before the New Year, Administrator Ickes said:

"I approve heartily of the Petroleum Industry War Council's resolution endorsing the Treasury Department's drive to have 30 million employees of all industries buy War Bonds at the rate of at least 10 percent by the New Year.

"Knowing how well the petroleum industry has heretofore co-operated in the war program, I expect to see it in the vanguard of U. S. industries meeting the Treasury's goal."

A PAIR THAT CAN'T BE BEAT!

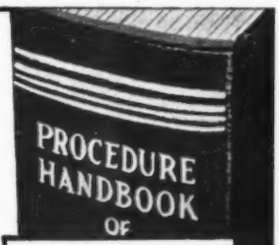
. . . And it's a pair that is teaming up on more and more rigs to give more efficient, safer operation.

EFFICIENT? The Abercrombie Pressure Gauge tells in billboard figures the exact pressure at all times on mud, water, oil, gas, or any liquid line. Movement of dial is minimized. Accurate reading is easy at a glance from 30 feet. Pressure gauging is out of the delicate instrument class.

SAFER? The ABERCROMBIE SHEAR-RELIEF VALVE protects pump parts from hazardous pressures. Should pressure go too high, the nail shears, valve piston moves out of path of flow and is harmlessly released through valve outlet. Replacement part? A common nail! Compare that cost with the cost of pump part replacements.

ABERCROMBIE PUMP COMPANY • GULF BLDG. • HOUSTON, TEXAS

New Book on
ARC WELDING



New Edition "Procedure Handbook of Arc Welding." Bigger than ever. Wider in scope. Latest information on all phases of arc welding—the ace process of war production and key to progress and increased earning power in post-war era.

Authoritative. Recognized the world over as the "bible" on arc welding design and practice. Many thousands in use by welders, designers, engineers and shop managers. Standard text in hundreds of schools and colleges.

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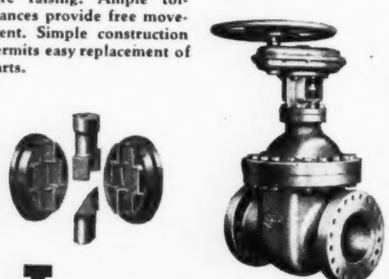
Up from Texas, 300,000 barrels of "galloping petroleum" will reach Illinois daily on its way to Eastern refineries. The world's biggest oil pipeline—"Big Inch"—will carry this mighty flow of oil. To control and direct it, the world's most dependable valves were specified—rugged, efficient Ludlow Valves. Built for service far into the future, Ludlow Valves will assure the smooth, trouble-free performance that has made them the first choice in the toughest of assignments. Let Ludlow give you value in valves. Send for Catalog.

THE LUDLOW VALVE MFG. CO., INC.
TROY, NEW YORK

Construction features: Self-releasing 30° angle wedges and free-floating gates, self-adjusting to seats, afford smooth action, tight closure, long service regardless of frequency of use. Rings cleaned throughout stroke action. Gates are wedge-locked directly opposite ports and completely unwedged before raising. Ample tolerances provide free movement. Simple construction permits easy replacement of parts.

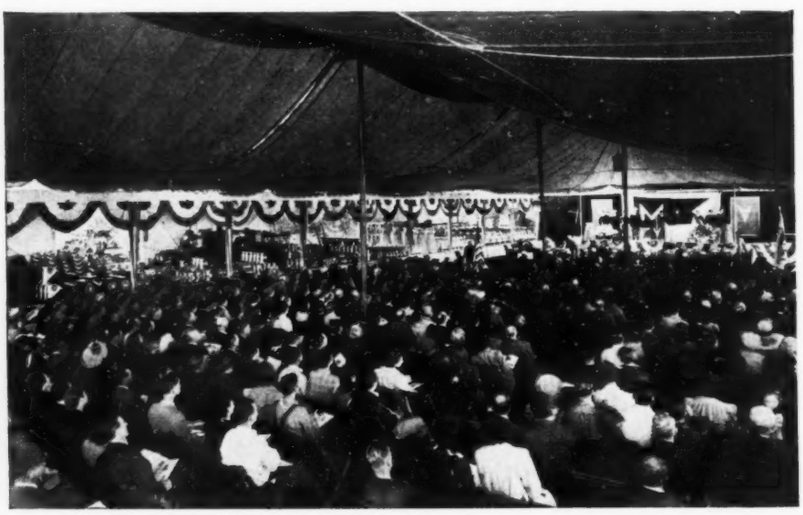


LUDLOW VALVES
SINCE 1866 PV9

Security Engineering Receives "M" Award

The highest honor bestowed by the United States Maritime Commission—the "M" burgee—was awarded recently to the Security Engineering Company, Inc., of Whittier, California, in colorful ceremonies held at the plant and attended by an enthusiastic audience of about 2000 persons. In addition to the Maritime "M," the Commission awarded the Victory Fleet Flag and Labor Merit Badges to employees of the firm in recognition of their outstanding production achievements. The honors were awarded for Security's excellent record in converting from peace-time manufacture to war production, for the originality of production methods employed, for simplification of product design that further increased production, and for the high standards of quality maintained from the very first despite difficult production schedules. The ceremonies were attended by a number of military and government officials including Charles E. Walsh, Jr., Chief of Procurement Section, Production Division, United States Maritime Commission, Washington, D. C.; H. C. Acker, United States Maritime Commission, Oakland, California; Com-

(Left) Charles E. Walsh, Jr., Chief of Procurement Section, Production Division, United States Maritime Commission, Washington, D. C. (Center) W. E. Sievers, executive vice-president of Security Engineering Company, Inc. (Right) Otto Hammer, vice-president and chief engineer of Security Engineering Company



Shown above is a part of the 2000 persons who attended Security Engineering Company, Inc., ceremonies at which the Maritime "M" Burgee was awarded

mander J. C. Arnold and Lt. Commander Clarence Froome of the United States Navy; Major C. W. Clark of the United States Army; Commander C. W. Thomas and Lt. Max Sturges of the United States Coast Guard. James Vandiveer, director of special events for Radio Stations KFI and KECA, acted as master of ceremonies and appropriate music was provided by the Eleventh Naval District Coast Guard Band under the direction of Rudy Vallee, bandmaster.

Charles E. Walsh, Jr., presented the Maritime "M" pennant and W. E. Sievers, executive vice-president, accepted.

Considerably before Pearl Harbor, Security Engineering Company, Inc., foresaw the necessity of all industry engaging in full capacity in war production and began the manufacture of steel valves and fittings and other ship materials for the shipbuilding program. The company has sufficient volume, making it possible to ship these materials to all parts of the United States.

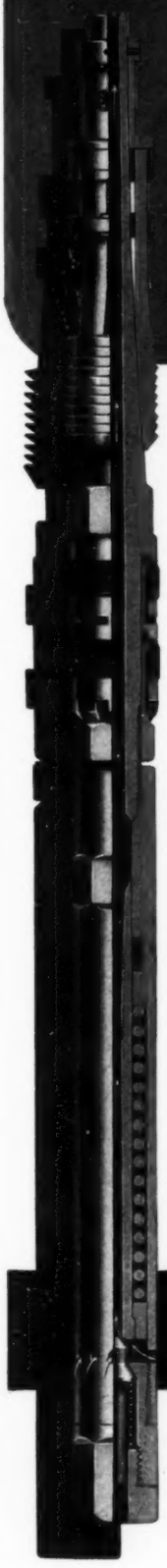
Graves General Manager D. W. Haering & Company

HOWARD B. GRAVES

D. W. Haering and Company, Inc., Chicago, Illinois, announces the appointment of Howard B. Graves to the position of general manager of the company. Graves joined the company in 1934 as senior technologist and was formerly the St. Louis district manager. His extensive background in the chemical engineering field thoroughly qualifies him for the general managership of the company.

REFINERY SUPERINTENDENT—Capable of construction and operation of moderate sized plant. Good possibilities of expansion. Remote location. Mechanical knowledge desirable. Give details of training and experience. Box A, care of *The Petroleum Engineer*, Allen Building, Dallas, Texas.

RIGHT NOW
IS THE TIME TO
STOP
SURFACE FREEZING
with an



OTIS REMOVABLE
BOTTOM HOLE REGULATOR

No more surface freezing — no more expensive heaters — no more high surface working pressures, with Otis Removable Bottom Hole Regulators. The time to install them is RIGHT NOW.

By removing the point of pressure reduction from the surface to a safe sub-surface level, natural formation heat absorbs all temperature losses resulting from gas expansion. The tubing becomes a "mile long" heater, the most practical and reliable heater known.

Predetermined low surface pressures are maintained and the rate of production is changed simply by adjusting the surface choke.

The Otis Bottom Hole Regulator is run and pulled on an ordinary steel measuring line, under pressure. Otis Service Crews are available for installation in most high pressure areas.

Write for Complete OTIS *Information and Details*

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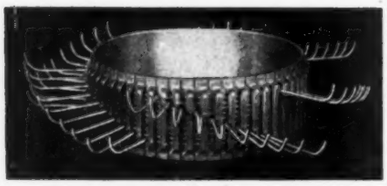
For a

CLEAN WELL

use

B and W, Inc.

WALL CLEANING GUIDES

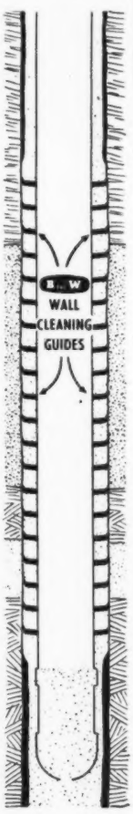


. . . and MOVE THE CASING WHILE CEMENTING

By mounting B and W Wall Cleaning Guides on the casing slightly below, through and above the productive sections which are to be gun perforated, continuous centering is assured throughout these critical sections. The strong, torque spring action of the multiple wires forming the guides holds the casing definitely in the center of the hole.

By raising and lowering the guide-equipped casing while circulating and cementing, the annulus between the casing and formation is freed from rotary mud and mud cake, and a perfect bond is secured between cement and formation.

B and W Wall Cleaning Guides . . . (1) Scratch off Mud Cake; (2) Center the Casing; (3) Prevent Channeling, and (4) Increase Successful Completions.



BRUCE BARKIS — B and W, Inc. — KENNETH WRIGHT

Well Completion Specialists

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New Division Manager Announced by Kobe

The appointment of R. G. Ralph as new Mid-Continent division manager has just been announced by H. K. Browning, general sales manager of Kobe, Incorporated. With this promotion came the appointment of H. K. Ihrig, former Tulsa district manager, as Ralph's successor as manager of the company's Technical Service Department in the Mid-Continent area. In making this announcement, Browning said these changes were made to meet the increasing demands of the company's business due to rapidly spreading use of the Kobe hydraulic pumping system for the production of crude oil essential to the war effort.

R. G. RALPH

Ralph, a graduate of Phillips University, brings to his new position a wide experience in oil production technical and sales problems. His first association with the production business was with Phillips Petroleum Company in 1929 and led to activities in the field of general production practices and later in the specialized technical study of treating crude oils in the entire southern di-

H. K. IHRIG

Why *manpower* should wield the "big stick" in this mechanized age! We are planning an army of 7½ Million in 1943. The drain from industries' 65 Million and the farms' 10 Million workers makes *manpower* the nation's number one problem. The more workers are needed the fewer there are to be had, presenting a problem so vitally important that some means of fortifying this weakening giant is soon due.

It is said that it takes 18 men in the rear to keep one man at the Front. This means that like the cog in a wheel every man must fit in his proper place and "stay put." But that's a job for the *manpower* commission. That it will be solved no one doubts.

It's everybody's job, though, to keep the wheels of war industries rolling so the cogs can fit for the long pull ahead.

Join the "Ten Percenters"
Buy More and More Bonds
Buy Till It Hurts, Then
Buy Some More

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We've joined up!
HOTEL GALVEZ . . . Galveston, Texas
Now used exclusively by U. S. Coast Guard.
No guests taken 'til Victory has been won.

Affiliated NATIONAL HOTELS
HOST TO THE NATION
SERVING 10 STATES AND OUR NATION'S CAPITAL

vision of the company, for which he was later responsible. In 1937, Ralph joined the Clymer Company as sales manager and in 1939 became associated with Kobe, Incorporated, as a specialized sales engineer, and more recently has been responsible for the company's entire Mid-Continent technical activities as manager of Kobe's Technical Service Department.

Ihrig also brings to his position an extensive experience in oil country production and technical methods. After attending the Missouri School of Mines and the Engineering School of Oklahoma A. and M., Ihrig went to work as a petroleum engineer for the Wilcox Oil and Gas Company and later the Phillips Petroleum Company in Oklahoma City. Interest in petroleum engineering led to his association with the technical staff of one of the oil country's trade papers. In 1936, he became interested in the development of special equipment for the treatment of emulsified crude oils and studied problems involving nearly all Mid-Continent producing states.

F. L. Wiegand of Oil Well Supply Passes Away

Frank L. Wiegand, 64, assistant treasurer of Oil Well Supply Company, died January 11 at his home in Dallas, Texas. Born in Butler, Pennsylvania, he joined Oil Well Supply Company in

FRANK L. WIEGAND

1898 as bookkeeper at the company's Butler store. In 1921 he was appointed district manager at Shreveport, and in 1929 was transferred to Tulsa as director of merchandise. Holding positions of responsibility at Tulsa and Dallas, where he moved in 1932, Wiegand became widely acquainted throughout the oil fields of the Mid-Continent and Gulf areas.

He is survived by his widow, a son, and a daughter.

Every Lunkenheimer valve is regularly tested on both sides at low and high pressure for seat tightness, and then given a shell test. The slightest leak causes rejection. Test pressures far exceed rated pressures.

But

The Final Test of a Valve . . . is Performance

How does it hold up in service? Does it stand the gaff of hard usage? Is it dependable? Is it economical to use? How does it stack up in *lasting* qualities? The answers to these questions are the final and only convincing test of a valve. Ask any production man.

Now, when performance is more important than ever, when unnecessary time out for repairs is waste, and when new valves aren't so easy to replace, valve users are profiting from their foresight in buying Lunkenheimer.

Rigid testing procedure is but one of the many precise steps in manufacture by which Lunkenheimer has maintained valve quality through the years. These steps are your assurance that once installed, Lunkenheimer Valves will give you more in uninterrupted performance for today's non-stop production schedules.

Since virtually all materials used in the manufacture of valves are on the list of critical materials, valve users are urged to furnish the highest possible preference ratings and proper "end use" information on their orders. This will be of mutual helpfulness.

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

LUNKENHEIMER VALVES

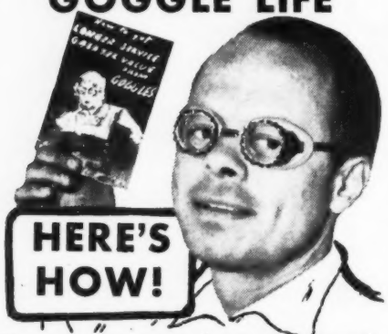
GET ACCURATE RESULTS
Quickly . . Easily . . with
CURTIN CENTRIFUGES

No. 3480. 100 c. c. machine. Cranks and heads interchangeable with 15 c. c. machines.

You can maintain your required speed for the period of the test with much less effort. Curtin centrifuges, proven world-wide, are heavy duty, rigidly constructed, and extremely simple in design. Illustrated bulletin, giving full details, available upon request.

W·H·CURTIN & CO. Inc.
HOUSTON U·S·A TEXAS

CARE LENGTHENS GOGGLE LIFE



You can ease your goggle procurement problems and lower goggle costs by giving attention to a few, easy-to-use items for maintenance. As headquarters for "Everything in Safety," Bullard offers these ideas in an illustrated booklet, "How to get Longer Service and Greater Value from Goggles." Free. Send for your copy!

E. D. BULLARD COMPANY
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Everything BULLARD in Safety

Please send me illustrated booklet, "How to get Longer Service and Greater Value from Goggles."

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NATIONWIDE SALES AND STOCKS

Crane Workers Win Army-Navy "E"

Nearly 15,000 more Chicagoans soon will become wearers of the Army-Navy "E" by the award of that high honor to Crane Co. and its employees. Unlike most "E" winners gaining it for outstanding production of arms and munitions, the Crane plant is being cited for high achievements in meeting vast wartime demands for its regular products, namely, valves, fittings, and piping accessories.

Crane Co.'s president, J. H. Collier, who will acknowledge Army-Navy "E" citation for 15,000 valve makers

The citation brings to light the company's foresightedness even prior to Munich, in gearing itself for greatly expanded production activity. Sensing then a definite possibility of increased need for its products, a program resulting in better and faster manufacturing of valves was immediately begun. Throughout the expansive plant situated on Chicago's southwest side, production effort was steadily intensified as new equipment was added and manpower multiplied. When threat of war became a reality, no conversion was necessary, merely greater concentration on the part the plant would play in arming the Nation and its allies.

All employees will be invited to the "E" presentation ceremony scheduled later this month. Representative workers will be elected to receive the award. Acceptance of the "E" burgee to be flown over the plant will be made by J. H. Collier, president of Crane Co., for many years vice-president in charge of manufacturing to keep non-productive time at a minimum, and for the convenience of the greatest number of employees, the short but impressive award ceremony will take place between shifts. Complete details including the roster of Army and Navy representatives to be in attendance will be released at a later date.

IT WILL

SAND-BANUM will remove and prevent scale and corrosion.

SAND-BANUM won't hurt personnel or equipment.

It is guaranteed to be Absolutely Harmless, and may be used without any danger or injury of any kind to boilers, tubes, packing, etc. It cannot damage clothing or injure skin, eyes or any part of the body. It is free of acids and other injurious ingredients. Contains no ammonia, graphite, water-glass, soda, lye, potash or chloride.

It is a pure vegetable compound made of tropical resins which are constant under heat. Consists of nothing but active ingredients, eliminates need of water analysis, automatically functions regardless of water or operating conditions.

"The Entirely Different Boiler and Engine Treatment"

SAND-BANUM is so easy to use, so certain in action, so competent in concentrated conservation. On this basis we invite your inquiry and test.

AMERICAN SAND-BANUM COMPANY, Inc.
9 Rockefeller Plaza, New York City

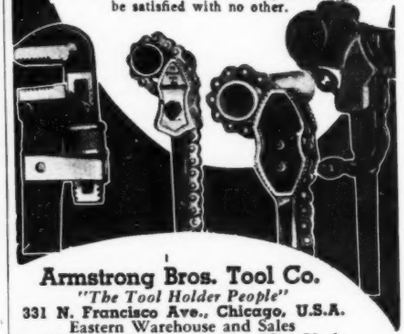
Look for the Arm and Hammer
ARMSTRONG BROS.

PIPE TONGS

Not only the type Tongs you want in the size and design you prefer — but the quality that distinguishes an "ARMSTRONG BROS." PIPE TOOL.

Chain Tongs with handles forged from high carbon steel, Drop Forged jaws with milled teeth, hardened, tempered and tested for wearing qualities, large Hardened Steel Bolts, Alloy Steel Shackles, proof-tested Chains, and the ARMSTRONG Design that gives far more bearing of jaws on bar.

All-Steel Pipe Wrench. This patented all-steel pipe wrench has 10 improved features including—elimination of cumbersome housing. Heavy forged-in lugs reinforced by reversed nut to take up side strain. Replaceable tool steel jaws. Perfect balance in all sizes. Try one and you will be satisfied with no other.



Armstrong Bros. Tool Co.
"The Tool Holder People"
331 N. Francisco Ave., Chicago, U.S.A.
Eastern Warehouse and Sales
199 Lafayette Street New York

T. R. Miller Promoted by Bethlehem Supply Co.

T. R. Miller, formerly special representative for Bethlehem Supply Company in the Gulf Coast area, was recently promoted to resident manager

T. R. MILLER

for Bethlehem Supply Company at Houston, Texas, and will be in charge of their sales office. Miller succeeds C. H. Seger, Jr., who has enlisted in the Navy.

Miller is a native Tulsan, having graduated from Tulsa Central High School in 1920. His first business experience was in banking.

He received his first supply company experience when he joined one of Bethlehem Supply Company's predecessors in 1928. Since that time he has served in various capacities throughout the Mid-Continent area. His service has included sales and management in the following boom fields: Seminole, Maud, and Konawa area, Oklahoma; East Texas; Wichita and McPherson, Kansas; Ada and Fittstown, Oklahoma, and Hebbronville, Texas.

In 1938, he was transferred to San Antonio, Texas, as a special representative and opened Bethlehem Supply Company's sales office at that point. He was transferred to Houston in 1939 as a special representative specializing in tubular sales in that area. He has a wide acquaintance throughout the entire Mid-Continent area.

Directory of Chemists

The Association of Consulting Chemists and Chemical Engineers, 50 East 41st Street, New York, New York, has issued the 7th revised edition of its Classified Directory. The association acts as a clearing house for consultants and in this directory are listed the names, addresses, and qualifications of consulting chemists and chemical engineers. A copy of the directory may be obtained free by applying to the office of the association in New York City.

Amercoat A NAME EVERY ENGINEER SHOULD KNOW

...protects vital chemicals in shipment and storage

AMERCOAT... the cold-applied plastic coating... solves the problem of handling chemicals in available tanks and equipment which, otherwise, would not be suitable for this purpose.

Amercoat protects tanks and equipment from corrosion and the contents from contamination by providing an inert plastic surface which is oderless, tasteless and dielectric to a high degree. Amercoat may be applied to any metal or concrete surface.

PROVIDED IN MANY INDUSTRIES

Amercoat has successfully solved problems of corrosion or contamination in the Chemical, Petroleum, Food, Maritime and many other industries.

Typical examples of the effectiveness of Amercoat are shown in the chart on the left.

All Amercoat products are compounded and pigmented to best meet stipulated problems. Tell us your problem and we'll answer it with Amercoat to meet your specific needs...or we'll tell you Amercoat is not the answer.

Amercoat is fully described and some of its many uses are illustrated in an interesting, informative booklet.

Write for your copy today.

SOME AMERCOAT LABORATORY TESTS

PRODUCT	TIME EXPOSED	CONDITION
100 Octane — Aviation Gasoline	5 yrs.	O.K.
Ammonium Nitrate	6 mo.	O.K.
Formaldehyde	1 yr.	
190-Proof Grain Alcohol	1 yr. 9 mo.	O.K.
Caustic Soda	1 yr.	O.K.
Vegetable Oil	2 yr. 1 mo.	O.K.
10% Sulphuric Acid	1 yr. 9 mo.	O.K.
Butyl Alcohol	1 yr. 9 mo.	O.K.
Methyl Alcohol	1 yr. 9 mo.	O.K.
Ammonium Sulphate	1 yr.	O.K.
Tannic Acid, 10%	1 yr. 9 mo.	Good
Ammonium Chloride	1 yr. 9 mo.	O.K.
Fish Oil	1 yr. 9 mo.	Good
Calcium Hydroxide	1 yr. 9 mo.	O.K.
Mercuric Nitrate	2 yrs.	O.K.
Sea Water	1 yr. 9 mo.	O.K.
Sodium Chloride	1 yr. 9 mo.	Fair
Potassium Sulphate	1 yr. 9 mo.	O.K.
Potassium Nitrate	1 yr.	O.K.
Lead Acetate, 10%		

Amercoat DIVISION AMERICAN PIPE AND CONSTRUCTION CO.

P.O. BOX 3428, TERMINAL ANNEX • LOS ANGELES, CALIFORNIA

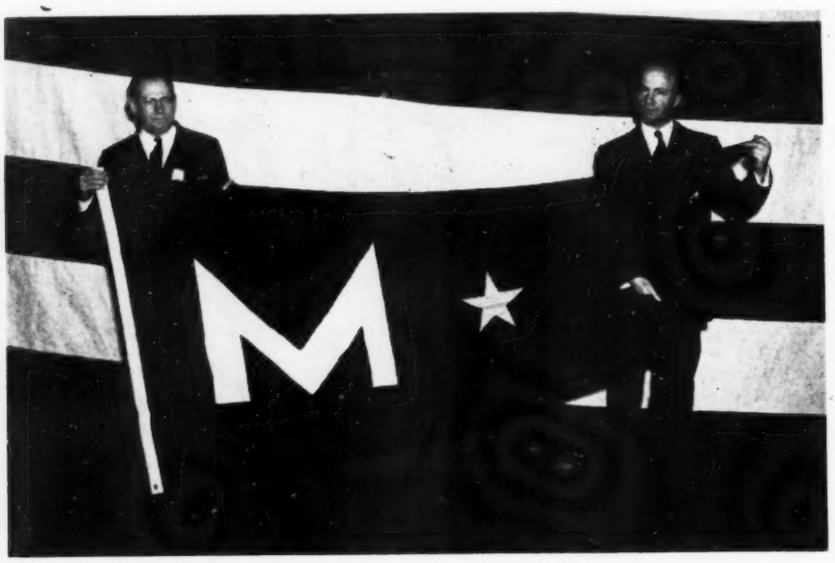
Superior Engine Division of National Supply Receives Maritime Award

Presentation of the U. S. Maritime Commission awards in recognition of outstanding production achievement was made to the Superior Engine Division of The National Supply Company at ceremonies held in Springfield, Ohio, recently.

In presenting these awards, Rear Admiral H. L. Vickery, vice chairman of the U. S. Maritime Commission, said that The National Supply Company was one of the first concerns in the nation to "jump in at the beginning" and "hold the line while industry as a whole was catching up with wartime demands."

A. E. Walker, president of The National Supply Company, accepted the "M" Pennant and the Victory Fleet Flag from Admiral Vickery on behalf of the employees of the Superior Engine Division of the company. "We are grateful," he said, "for this recognition of a patriotic effort to serve our country in time of war. What has been done is only a good beginning, and we promise that past records will not only be maintained, but will be excelled in the future."

After the presentation of Employee Merit Badges, which were accepted on behalf of the employees by P. J. Shouvlin, founder of the Superior Engine Company, refreshments were served to more than 1800 employees and their guests.



Rear Admiral H. L. Vickery, vice-chairman, U. S. Maritime Commission (left); A. E. Walker, president, The National Supply Company (right)

V. H. McKimmey Made Purchasing Agent Texasteel

V. H. McKimmey has been appointed purchasing agent for the Texasteel Manufacturing Company at Fort Worth, Texas. He is well known in supply circles, having been with Lucey Manufacturing Company in Tulsa, Oklahoma, and the National Supply Company in Fort Worth for a number of years.

Save Critical Materials— Lessen Drilling Grief— With Acme's Mud Collar

Makers of the world famous "Drilmor" Line of Drilling and Fishing Tools for Cable Drillers - the Highest Standard of Quality Since 1900

There are few Mud Collars in stock. You know the difficulties of obtaining *critical materials*. And, too, Acme is now in war production. So, don't delay placing your Mud Collar order—as deliveries from *new stock* cannot be promised for "the duration."

Here's what Acme's Mud Collar can do for you—as proven by satisfied users—in any formation:

It lessens drill pipe torque; assures faster, easier cutting, longer runs, fewer "green bits" and makes better hole.... Its 6 high-velocity fluid streams keep cutters clean, bit bearings "lubricated" and free of cuttings—while constantly flushing bottom.... In sticky formation, it also prevents mud rings and "balled up" bits.

Decrease material purchases by increasing the life of bits and drill pipe. Learn how—with this "wonder tool." Write TODAY for full information. *And don't delay your order. (Also ask for Catalog No. 12. It gives valuable information on correct use and care of Acme cable tools.)*

With Acme's facilities largely devoted to war production, Defense comes FIRST! But we'll serve YOU as best and long as we can—and in friendly fashion.

The Acme Fishing Tool Co.
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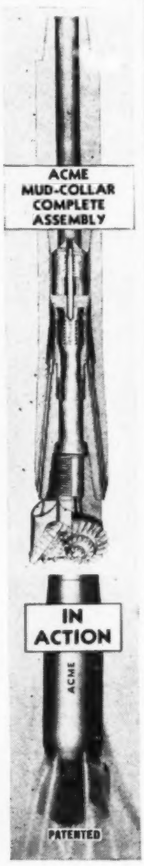
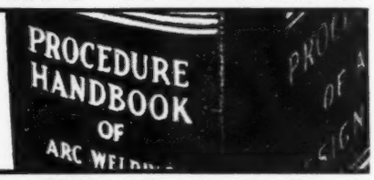
Export Office: 19 Rector St., New York, N. Y.



New Book on ARC WELDING



New Edition "Procedure Handbook of Arc Welding." Bigger than ever. Wider in scope. Latest information on all phases of arc welding—the ace process of war production and key to progress and increased earning power in post-war era.

Authoritative. Recognized the world over as the "bible" on arc welding design and practice. Many thousands in use by welders, designers, engineers and shop managers. Standard text in hundreds of schools and colleges.

1308 pages • 1810 illustrations
Size 6" x 9" x 1 3/4"

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($2.00 outside U. S.)

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Mail order and check to
THE PETROLEUM ENGINEER
Box 1589, Dallas, Texas

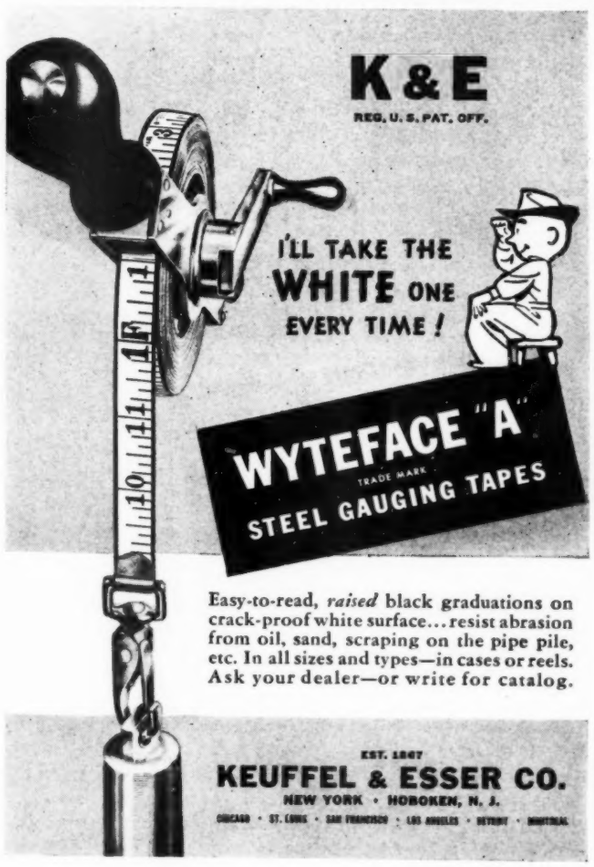
Fluor Gives Dinner Dance for Employees

To indicate its gratification for the coöperation, loyalty, and hard work of their employees in furthering the company's huge amount of war work during the last year, on Tuesday before Christmas Day, 1087 employees, their wives, husbands, and dinner partners were guests at an evening dinner dance given at the Biltmore Bowl of the Biltmore Hotel, Los Angeles, by the management of The Fluor Corporation, Ltd.

The company engaged the entire Bowl, Joe Reichman's orchestra, and floor show for its exclusive use for the pleasure of its employees and employees' guests. Two features of the evening were the drawing of two door prizes—a man's wrist watch and lady's wrist watch, contributed by the company's Cooling Tower Division Mill, and a drawing of War Bonds for employees only, donated by the management.

P. E. Fluor took the opportunity at that time to introduce Shirley E. Meserve, of the legal firm of Meserve, Mumper and Hughes, who was recently elected vice-president and member of the Board of Directors of The Fluor Corporation, Ltd.

More than 1000 enjoyed the dinner dance given by The Fluor Corporation, Ltd.



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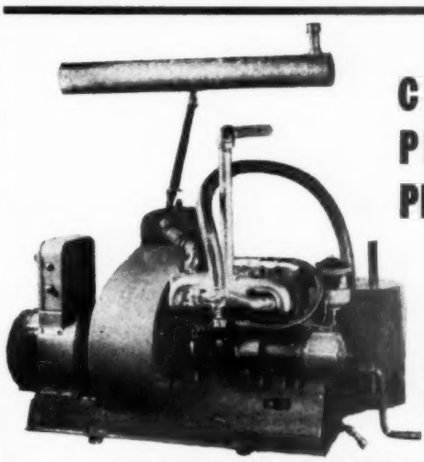

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MINNEAPOLIS, MINNESOTA
America's Leading Manufacturer of Pipe Line Cathodic Plants

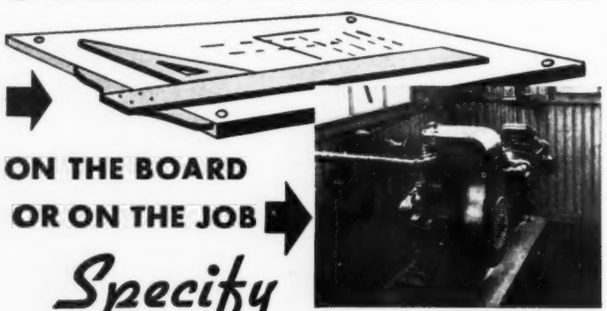
Everybody . . .
Every Payday . . .

10%

IN WAR BONDS

Along with increased war production goals go increased costs . . . extra billions which must be raised, and raised fast, to win this war. That means we must raise our sights all along the line, with every firm offering every American with a regular income the chance to buy more War Bonds. YOUR help is asked in encouraging employees to put at least 10 percent of their pay into War Bonds every pay day, through the Payroll Savings Plan.

U. S. WAR SAVINGS BONDS



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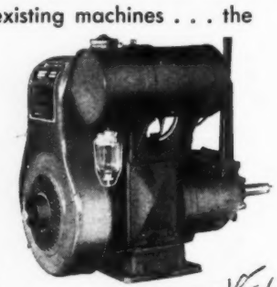
In the development of new equipment, as well as in the efficient utilization of existing machines . . . the power factor is more important today than ever before. That's why Wisconsin Heavy-Duty Air-Cooled Engines rate *Number One Consideration.*



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Single cylinder air-cooled engine. 3 to 5 hp. Other types and sizes, 1 to 35 hp.

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OIL FIELD DISTRIBUTOR FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS

TRADE LITERATURE

What to Write For

DOWELL, INCORPORATED, Kennedy Building, Tulsa, Oklahoma, has just released the first issue of the war-time format of The Acidizer, which differs from previous publications of the booklet in that it is now a single sheet. The war-time form of the booklet deals with one specific problem in each issue, whereas the former booklet of 8 or 10 pages was intended as a contribution to the literature on acidizing and other chemical service for the oil and gas industry.

WAUKESHA OIL FIELD ENGINE BULLETIN 1079 may be obtained from Waukesha Motor Company, Waukesha, Wisconsin. This publication describes the company's power units for oil-field operations. The units are multi-fuel engines and are especially adaptable to fuel changes sometimes necessary for use on drilling rigs at various locations.

HOW TO CARE FOR MOTORS, GEA-2856A, is the latest booklet issued by General Electric Company, Sec. W750-179, Schenectady, New York. The booklet is reported of value to supervisors and maintenance men on how to get the most out of motors, old or new, and contains facts to aid in setting up a maintenance program to keep up with today's unprecedented demands; switching motors from one job to another, and equipping machines with new motors.

E. D. BULLARD COMPANY, 275 Eighth Street, San Francisco, California, offers its illustrated booklet "How to Get Longer Service and Greater Value from Goggles."

THE ACME FISHING TOOL COMPANY, Parkersburg, West Virginia, offers Catalog No. 12 without obligation, containing valuable information on correct use and care of Acme cable tools. According to the manufacturer, the Acme mud collar lessens drill pipe torque, assures faster, easier cutting, longer runs, fewer green bits, and makes better holes. Its high-velocity fluid streams keep cutters clean, bit bearings lubricated and free of cuttings, while constantly flushing bottom. The collar is also reported to prevent mud rings and balled-up bits.

TYPE 2400 and 248P and other Level-Trol types for all service applications are described and illustrated in Bulletin F-1, issued by Fisher Governor Company, 602 Fisher Building, Marshalltown, Iowa. Copies of the bulletin will be supplied on request. According to the manufacturer, this equipment is extremely sensitive, offers trouble-free operation, quick response to level change, a throttling range adjustment that makes possible a wide variation in level change necessary to actuate valve or instrument, and a level position adjustment that permits the operator to maintain liquid-level range anywhere within the length of the float.

CRANE CO., 836 South Michigan Avenue, Chicago, Illinois, offers its series of educational bulletins "Piping Pointers" free on request. The bulletins are designed to accomplish three things: Train new men for piping maintenance work, get better service from piping equipment, and conserve critical metals.

CATALOG 2942, published by Young Radiator Company, Racine, Wisconsin, is just off the press and will be sent on request. The catalog describes and illustrates the Vertivent heater and ventilator, designed and developed by Young to meet the many requests for this type of equipment for installation in war production plants.

E. C. Lane Passes Away

E. C. Lane, chemist with the U. S. Bureau of Mines, died recently at his home in Bartlesville, Oklahoma, as the result of a heart attack. He was 62 years old. Lane joined the Bureau of Mines in 1919 at the San Francisco laboratory, being transferred in 1924 to the Petroleum Experiment Station at Bartlesville.

E. C. LANE

He was born September 30, 1880, in Livermore Falls, Maine. In 1904 he received an A.B. degree in chemistry from Bates College, Lewiston, Maine, and in 1912 the degree of master of science from the University of California.

Before joining the staff of the Bureau of Mines he taught chemistry in Pomona College, Claremont, California; spent two years in Changsha, China, teaching chemistry in the college there, and for three years he was in Honolulu as a research and analytical chemist in the sugar industry.

He was an active member of the American Chemical Society.

J. S. Ross Killed in Accident

John Stanley Ross, petroleum engineer, Federal Power Commission, was killed January 1 when his automobile collided with a street car in Washington, D. C.. He was graduated from Leland Stanford University in 1917 with a degree in geology and mining. Except for a year during World War I, spent as an officer in the U. S. Army, Headquarters Detachment, 115th Engineers, A. E. F., he has been identified continuously with the professions of geology and petroleum engineering. Ross served successively as field geologist, Indian Territory Illuminating Oil Company (1917-18); resident geologist and petroleum engineer, Associated Oil Company, Coalinga, California (1919-21); geologist, Barnsdall-Foster, Billings, Montana (1921-22); petroleum engineer, U. S. Bureau of Mines (1922-25); engineer-in-charge, Geological Survey, Conservation Branch, Salt Creek, Wyoming (1926-28); senior petroleum engineer, Bureau of Mines, Shreveport, Louisiana (1928-30); engineer, Otis Pressure Control, Inc. (1930-36); consulting petroleum engineer, Works Progress Administration, Washington, D. C. (1937-39); petroleum engineer, Federal Power Commission, Washington, D. C. (1939-43).

J. S. ROSS

Interment, with military honors, was made in Arlington Cemetery January 4, 1943. Ross is survived by his widow and two daughters.

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...and they are equally efficient in YOUR plant!
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That's why it is doubly significant that in four out of every five YMS Minesweepers, Westco Pumps have been given the job of handling BOTH fresh and saltwater supplies. In addition, Westcos are going into Troop Ships, Sub-Chasers, Tankers, Coast Guard Cutters, and other naval vessels.
What better testimony is there to the amazing stamina, high efficiency, and rugged dependability built into Westco Pumps?
TAKE A TIP FROM THE NAVY. When you buy pumps for YOUR plant, remember—you can't beat Westco performance!
On Westco Pumps, wear and corrosion are taken by renewable liners. To renew pump, simply renew liners!
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Yes, "TOLEDO" tools have gone to war and we are proud of this fact. We know "TOLEDO'S" hundreds of thousands of old-time users will understand and excuse us when we say prompt shipments cannot be made of orders with low priority ratings, for America's war orders of course have the right of way.

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Book Reviews

Oil and Gas Field Development in United States 1941, Volume XII, published by National Oil Scouts and Landmen's Association, Austin, Texas. 790 pages.

This book is an annual review for 1941 of geological and geophysical prospecting, land and leasing activities, wildcat exploration, proved field development, oil and gas production, pipe line, and refinery statistics. In this volume of the book the editors have endeavored to meet the oil men's needs by presenting as much accurate, authentic information as space will allow in as concise manner and in as many diversified interests as possible.

Arkansas' Natural Resources—Their Conservation and Use. Copyright by The Source Book Committee, Fayetteville, Arkansas. 452 pages.

Manuscript for this book was prepared by specialists from the agencies of state and national government most directly concerned, together with other specialists in methods of teaching. The Arkansas State Planning Board assumed responsibility for co-ordinating the efforts of the various agencies that have contributed to the volume. The volume contains source material that should be useful in preparing courses of study on the distribution and conservation of Arkansas' natural resources.

Oil Property Valuation, by Paul Paine. Published by John Wiley and Sons, Inc., New York, New York. 204 pages, price $2.75.

"Published accounts of the valuation of oil properties have been concerned chiefly with the important element of the oil and gas contents of lands. Less attention has been given to those other influences which affect the value of the oil and gas, to the various valuation methods appropriate to different circumstances, and to the forms in which oil properties occur.

"The aim here is to help close that gap, especially for the younger engineers, with a review of the meaning and scope of valuation in the oil business, the factors which enter a valuation, and the methods of applying these. Questions which arise in valuation practice and the avenues of solution are discussed rather than efforts, in these days of rapid changes, to provide specific answers and detailed lists of equipment costs."

Private Generating Plant by "Proton." Published by Chemical Publishing Company, Inc., Brooklyn, New York. 151 pages, price $2.50.

A practical survey of the various types of generating plants now available, and with interesting and useful information for electrical engineers, consultants, electrical contractors, and students. The chief types of generating plants of small and medium sizes have been described in detail with diagrams of automatic and semi-automatic lighting sets included with separate chapters devoted respectively to the subjects of installation and maintenance.

Machine Speeds and Feeds, compiled by Hayward-Tyler and Company, Ltd., published by Chemical Publishing Company, Inc., Brooklyn, New York. 131 pages, price $2.25.

A collection of tables and data relating to machine operations on cast iron, steels and alloy steels, aluminum, and aluminum alloys, and other non-ferrous metals. The tables were compiled for the guidance of machine operators tackling new jobs or new materials. It has not been attempted to give information on the speeds and feeds suitable for treated tools. It should be noted, however, that in many cases it may be possible by the use of certain processes, to increase speeds or feeds and obtain the same tool life. The tables group the information required for each type of machine together in the easiest form for quick reference.

Plant Engineer's Manual, by E. Molloy. Published by Chemical Publishing Company, Brooklyn, New York. 231 pages.

"A comprehensive reference book for all engineers responsible for the installation, operation, and maintenance of industrial plants." The efficiency of factories and workshops depend greatly upon the efficiency and skill of the plant engineer. Information given in the book is designed to provide the plant engineer with a convenient source of reference upon all the main aspects of engineering, both mechanical and electrical, which he is likely to encounter in his everyday work.

Engineer's Pocket Book, by F. J. Camm. Published by Chemical Publishing Company, Inc., Brooklyn, New York. 492 pages, price $4.25.

In the present volume the author has endeavored to present a digest of the tables, formulae, and memoranda that engineers require in their daily work, and which normally require the consultation of several books. Most of the engineering pocket books have reached such a bulky proportion that it is somewhat difficult rapidly to locate the information to which it is desired to refer. The aim of the author has been to produce a compact volume.

Index of the pocket book is full and adequately cross-referenced, and appropriate subjects have been grouped.

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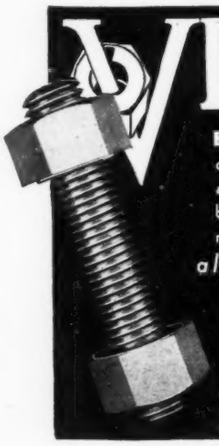

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MEETINGS

California Natural Gasoline Association, Monthly Meeting—February 4, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Institute of Mining and Metallurgical Engineers, Annual Meeting—February 15, 16, 17, and 18, 1943, New York, New York.

American Association of Petroleum Geologists, Annual Meeting—April 7, 8, and 9, Fort Worth, Texas.

American Petroleum Institute, Division of Production, Eastern District—April 8 and 9, 1943, William Penn Hotel, Pittsburgh, Pennsylvania.

Petroleum Industry Electrical Association, Annual Meeting—May 5 and 6, Houston, Texas.

Maritime "M" Award to Cooper-Bessemer

Fitting tribute was paid The Cooper-Bessemer Corporation at its Grove City, Pennsylvania, plant for outstanding production of Diesel engines and major engine parts for Liberty Ships, in the presentation of the Maritime "M", highest award of the United States Maritime Commission.

Significance was added to the occasion in the person of Rear Admiral Howard L. Vickery, vice-chairman of the U. S. Maritime Commission and Chairman of the Board of Awards, who made the presentation of the "M" award, one of the few ever to be given in this important phase of war production.

Admiral H. L. Vickery presenting the Maritime "M" Burgee to Gordon Lefebvre, vice-president and general manager of Cooper-Bessemer

The high degree of friendliness and coöperation existing between workmen and managers at both the Grove City, Pennsylvania, and Mount Vernon, Ohio, plants of the corporation was well expressed by Gordon Lefebvre, Cooper-Bessemer vice-president and general manager, who accepted the award on behalf of the organization.

Other high points of the program, which was carried by direct wire through loud speakers to workmen assembled at the Mount Vernon headquarters and also broadcast over radio stations in Pennsylvania and Ohio, included raising the Victory Fleet Flag and the Maritime "M" burgee, and presentation of the Maritime Merit Badge for each Cooper-Bessemer employee.

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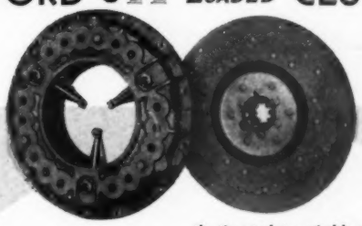

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